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ABBREVIATIONS. — D. = Discussion; I. = Illustrated.
Names of authors are printed in *italics*.

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CAST REINFORCED CONCRETE PILES.

BY SANFORD E. THOMPSON AND BENJAMIN FOX, MEMBERS OF THE BOSTON SOCIETY OF CIVIL ENGINEERS.

[Read before the Society, September 16, 1908.]

THE object of this paper is to give a description of the design, construction and data on driving cast reinforced concrete piles for a foundation of the Boston Woven Hose and Rubber Company's new power plant in Cambridge, Mass. Detail times of the various elementary operations were taken on twenty of the piles during the driving with a view to determining the best methods of driving cast reinforced concrete piles and to compare piles of slightly different design and especially to analyze the times and costs for future estimates. The results obtained from these observations are recorded in tables forming a part of this paper, and from them curves of some of the piles, showing the penetration during the driving, are drawn to illustrate the different methods of driving and the obstacles encountered. Times and costs upon construction work as ordinarily compiled are of comparatively little value for estimating the costs on subsequent jobs, although the data may represent a large amount of clerical labor, for the reason that the most important factors in fixing the costs are usually omitted.

CONCLUSIONS.

From the observations taken on this work the unit costs were determined as given on page 18, and also the following conclu-

sions in regard to methods were drawn. Although these conclusions may not all be of general application because drawn from one set of piles, they are presented just as they were given in the original report upon the work as furnishing suggestions of general value :

Arrange molding platform if possible so that butts of pile are placed to be drawn direct by pile driver.

Design butt so that pipe connection does not interfere with snatch ring. Place pipe connection so that hose can be connected before raising pile and supporting rope will not interfere with derrick hook.

If piles are made in cool weather and are to be driven in 30 days, strengthen concrete mix at butt by working some dry cement into it while ramming.

Use perfect rolls under driver to facilitate quick moving. The plan found best at Cambridge with the 4700-pound hammer was to begin driving by churning and water jet, using this method as long as possible. The chain connecting pile to hammer was then disconnected and driving began with hammer drop of about 2½ ft., increasing drop as driving became harder; 4 ft. may sometimes be used at the start.

In ground not too hard it may be advisable after completing churning to give the chain a slack for a ½ ft. drop, and raise pile a little with a jerk after each blow. This appears to be effective only in ground soft enough so that the pile can be readily raised, and as it takes time to adjust chain, is hard on engine, and tends to start head crushing, it is of very doubtful value.

As tip of pile should have good bearing on ground undisturbed by water jet, the water should be shut off before the pile is down to grade.

The 8-in. by 8-in. tip was found to be slightly preferable to the 10-in. by 10-in. tip in time of driving. The 2-in. jetting pipe gave the best results, and it is suggested for future use that this be reduced to 1 in. or 1¼ in. for the last 12 or 18 inches at the tip.

For piles of 30 ft. or less length the longitudinal reinforcement may be ¾-in. rods instead of ⅞ in., but for piles of over 30 ft. computations should be made so that the longitudinal reinforcement will be strong enough to stand the vibrating weight of the pile when it is being raised to the gins of the machine.

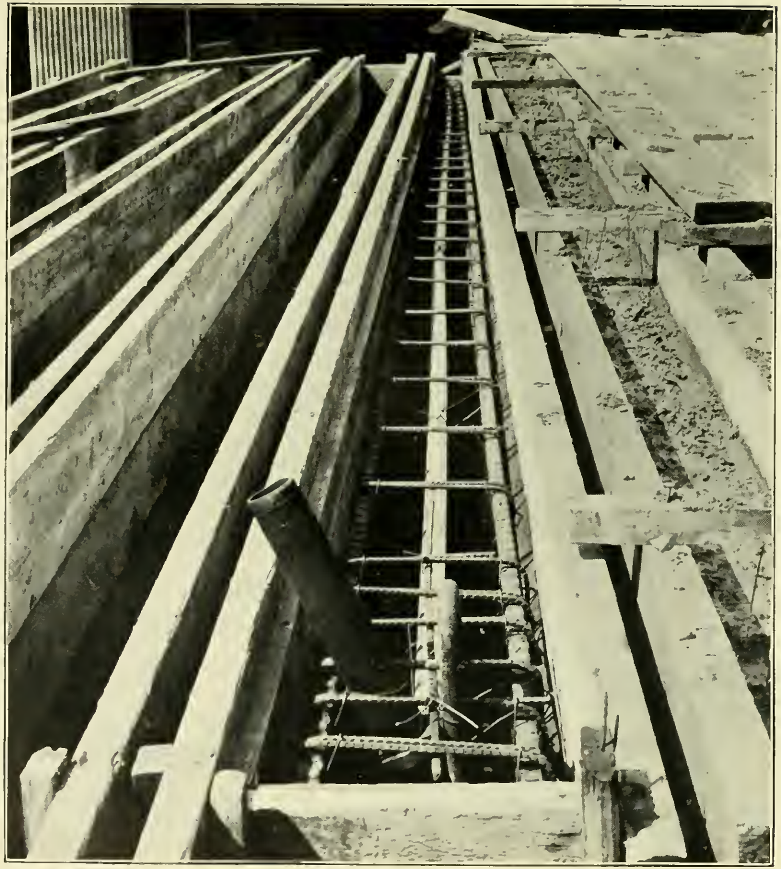

Fig. 1. View showing Forms for Casting Piles.

Fig. 8. Pile in Place, ready for Water to be Turned On.

Fig. 10. Pile with Head Smashed, Exposing Reinforcement.

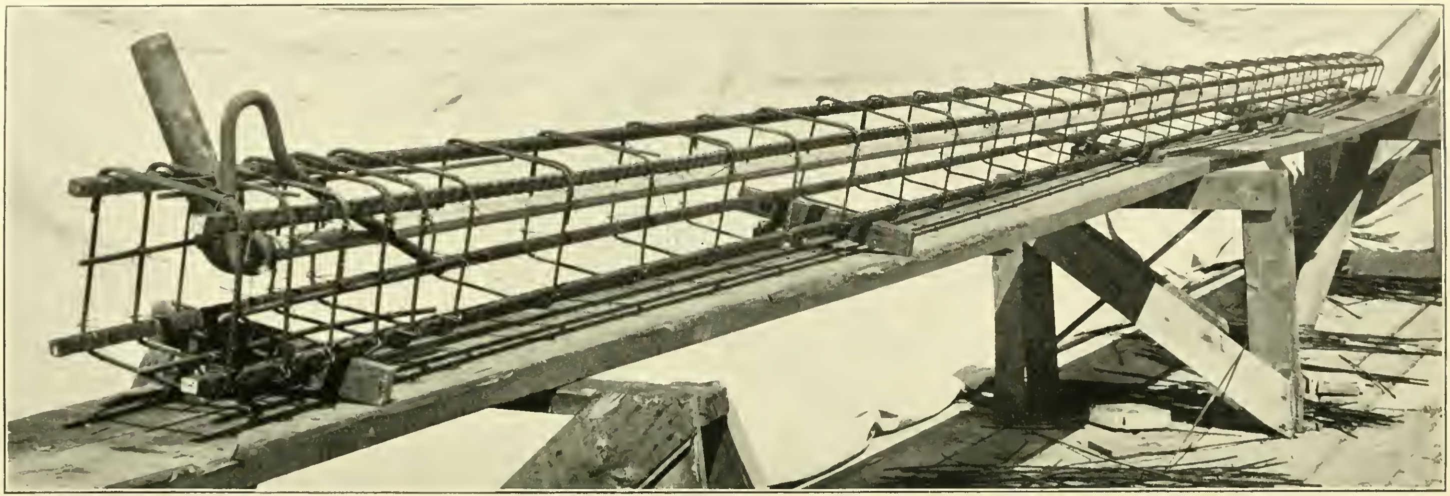

Fig. 3 Pile Reinforcement ready to Place in Form.

Design.

The piles as designed by Mr. Fox were made 30 ft. 6 in. long, 14 in. square at the butt end, and in general 9 in. square at the tip. A number of soundings were taken at the site of the power house which indicated a fill of from 6 to 8 ft.; below this to a depth of 29 ft. 7 in. to 31½ ft. from the surface, fine sand and mud (practically all may be considered sand); and below the sand a clay hard pan was reached which was tested to a depth of 13 ft. These tests, together with a consideration of the requirements, determined the length of the pile.

Size of Tip. Of the 48 piles which were made, 6 were 8 in. square and 6 were 10 in. square instead of 9 in. at the tip. The object of this variation in size of the tip was to determine which size gave the best results. The irregularity of the water pressure proved a very great handicap to making accurate comparisons and also affected very seriously the results obtained during the actual driving of each pile. Enough piles were observed, however, to give fairly good averages.

Averages of the time of actually driving the piles with different-sized tips give the following results, which indicate that the 8-in. tip is slightly preferable in time of driving. The variation in the character of the ground as well as the water pressure may influence in a measure the relative times.

Time Driving Piles with Different Sized Tips.

Size of Tip. Inches.	Range in Time Driving. Minutes.	Average Time Driving. Minutes.
8	26 to 107	66
9	22 to 166	76
10	40 to 130	85

Reinforcement. — Piles were reinforced with four ⅞-in. corrugated steel rods extending to within 2 in. of the ends of the pile, and imbedded 2 in. from the face near the butt and 1½ in. from the face at the tip. Loops of ¼-in. corrugated bars were placed around the principal steel, spaced about 12 in. apart except near the butt, where the spacing was decreased to 4 in., there being 34 loops in all. The butts of the piles were also extra reinforced, some with ⅜ in. and some with ½ in. rods, varying in length from 2 to 3 ft. A ⅞-in. rod about 5 ft. long was imbedded in the concrete with a loop sticking out through the concrete near the top of the pile on one side for hooking with derrick. Fig. 1 shows a view of the reinforcement wired up and placed in the form.

A galvanized iron pipe was cast in the center of the pile for the water jet. For experimental purpose the sizes of pipes were varied, being 2 in., $1\frac{1}{2}$ in., $1\frac{1}{4}$ in. and 1 in. To carry out the experiment still further some of the piles were made with one of the larger size pipes for about half the length of the pile and there connected with one of the smaller pipes which extended down to the tip.

Size of Jetting Pipe. — The times of driving piles with different sizes of pipe in the interior of the pile were plotted, but the variation in each due to other causes was so great that no practical conclusion could be reached. The results simply indicate that the pile with 1-in. pipe took slightly longer to drive than the piles with larger sized pipe.

The friction of water running through pipe of small size is very great, so that it is known without experimenting that the largest size pipe which it is practicable to insert in a pile will give the least loss of head and therefore be the best. To increase the velocity of the water, and thus increase its power to loosen earth (note that it is the velocity, not the pressure, which is increased), the size of the tube should be reduced near the tip. The reduction must be made far enough from the tip of the pile to prevent clogging under heavy blows. There is no danger of the nozzle filling while the water is flowing freely, and therefore no danger while the pile is being churned down in the first few blows. The danger is apt to occur when the driving becomes hard, and at this time the penetration per blow is so small that it would seem that a nozzle 12 in. long would be sufficient to prevent any material working up into the larger pipe. A 2-in. pipe is probably as large as is practicable, and it is therefore suggested that this size be used to within 12 in., or if preferred, 24 in., from the tip, and there reduced to 1 in.

Methods Used in Taking Time Notes.

Times and costs upon construction work as ordinarily compiled are of comparatively little value for estimating the cost on subsequent jobs. This is especially true upon work of an untried character, where, moreover, the records are of greatest interest. It frequently happens that even some of the most important factors in fixing the cost are omitted. In one case, for example, an elaborate tabulation of costs was made upon the construction of a storage reservoir, but the length of the haul, the height of the bank, the character of the earth excavated and the rates per day paid to the men were not given. In

other words, the data, although representing a large amount of clerical labor, were absolutely useless except for a job identical with the one upon which the records were taken, and a job identical with this was an impossibility, because the conditions mentioned would all differ to an appreciable extent on any two pieces of work.

On another large piece of construction carried on by a branch of the United States Government, the monthly records were carefully kept and the costs per cu. yd. figured out, but when supplies were purchased they were all charged on the date they were received, so that, if, for example, the cement for 10 000 yd. of concrete was received during a certain month, its cost would be divided into the cost per cu.yd. of the concrete laid during that month, even although two thirds of the cement was in storage for future use. Consequently, the unit price during one month might be double that for the next with the conditions substantially identical.

Even when the fundamental data are given in thorough detail, the times and costs are apt to be applicable only to another piece of work which is quite similar in character, not necessarily from carelessness, but because of the difficulty and the time required in separating and properly analyzing the different operations.

Some of the difficulties met with in such records are:

(1) Distinguishing between the times which are constant for any job and those which vary with the quantity of the work.

(2) Separating items which may be abnormally large or abnormally small on the job in question, so that allowance may be made for these particular items in future estimates.

(3) Omitting to separate the time necessarily wasted because of abnormal conditions or because the work is of a new and untried character.

To prevent such differences as these, and to avoid the errors resulting from them, Mr. Thompson, under whose supervision the recorded notes were taken, has used for a number of years the plan originated by Mr. Frederick W. Taylor in machine-shop work, of finding the elementary unit times on any piece of work in sufficient detail so that these unit times may be recombined in any desired arrangement. This enables the constants to be distinguished from the variables, abnormal times corrected, and lost time which will not occur on another job eliminated. Allowance also can readily be made for the time which is always necessarily lost during rests and ordinary delays.

To make such studies as these it was found necessary in many cases to record very small times, fractions of a minute, and as an ordinary timepiece or even the common form of stopwatch is very cumbersome, a stopwatch with a decimal dial, as shown in Fig. 2,* was designed on which the minutes are divided into hundredths instead of into seconds. With this the time is all recorded in minutes and decimals of a minute instead of in hours, minutes and seconds. Thus any of the times may be added together directly or multiplied. For holding the watches and the loose note sheets a case was designed in the form of a book, also shown in Fig. 2.

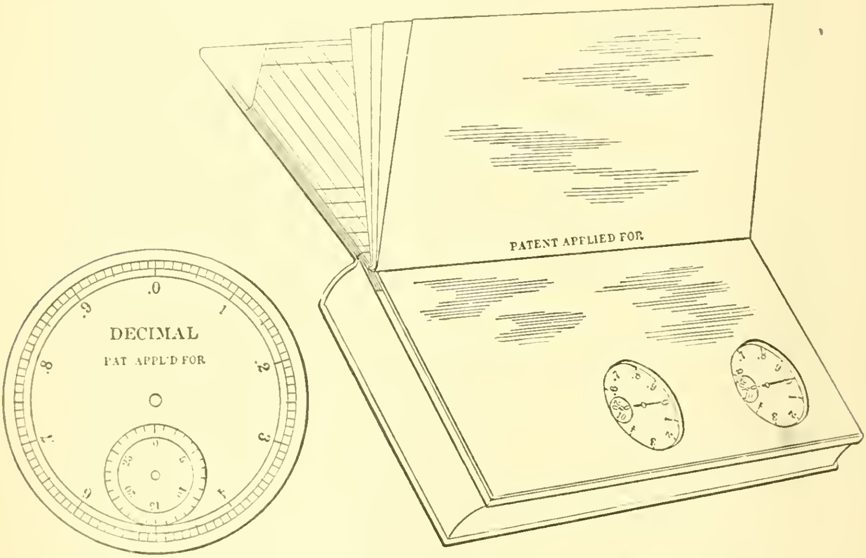

Fig. 2. Decimal Dial for Stopwatch, and Watch Book.

These remarks are somewhat aside from the subject under consideration, but may be of interest as showing the methods which have been adopted in certain cases for analyzing the times and costs of work of an intricate character.

In the pile driving at the Boston Woven Hose and Rubber Company's buildings, a complete analysis was made only upon the driving of the piles, no detail times being taken upon the making of the piles and items incidental to this. However, the costs of all the individual items were recorded carefully by the contractor, Mr. Fox, and, therefore, in the tabulation of costs

* Watches and method of use are further described in a paper on "Shop Management," by Mr. Fred. W. Taylor, Transactions American Society of Mechanical Engineers, Vol. XXIV, 1903.

the divisions are sufficiently minute to form a basis for estimating other jobs which differ in detail.

The operations of driving a cast reinforced concrete pile are similar in a general way to those involved in driving wooden piles, but the operation, or in many cases the lack of operation, of the water jet, and the somewhat greater care which must be used in handling the piles, considerably increase the labor, and particularly increase the amount of work getting ready to drive and the necessary delays incidental to the driving.

Detail Operations during Driving.

In order to correctly analyze such work as this and separate it into small enough operations to permit the adaptation of the times and costs to other jobs, very minute and exact records are necessary.

The records were taken by Mr. Thompson's assistant engineer, Mr. William O. Lichtner, with the aid of the decimal watches and the watchbook already referred to. When the pile drivers were about to start a new pile, each individual operation, such as moving pile driver, attaching rope to pile, pulling pile, raising pile vertically, and so on, was entered on the note sheet. In many cases each one of these operations became separated into two or three parts by delays or additional operations occurring in the midst of them, and these delays were also recorded with the time.

When the driving was actually begun, the number of blows of the hammer was recorded by a pocket mechanical counter, and the time required for each blow or for a series of five blows was entered on the note sheet, together with the height of the drop and the penetration, the latter being read from a scale painted on the gins of the pile driver. Of course any stops during the driving were noted, with the length of the stop and the cause. In Table B, Detail Times on Pile Driving, given as a folder at the end of this paper, the times for each operation are collected and recorded, together with the delays.

The unit operations while getting ready to drive were as follows:

Moving machine, attaching ropes, hauling pile from platform, attaching hose and ropes, raising pile vertical, placing pile, placing hammer, and delays.

During driving there were various delays which are tabulated under the heads of " Tending Machine," " Attaching Ropes," " Breaks in Hose," and " Miscellaneous."

In Table B also the method of driving is indicated under the heading of "Number of Blows." For example, in the first place the pile was allowed to penetrate, if it would, by its own weight and the aid of the water jet, as given in the column, "No Hammer." The hammer was then placed upon it at rest and it sank for another distance with the aid of slight churning. The third column under this heading gives the number of short blows made with the pile attached to the hammer, and the following column gives the number of short blows made in connection with the pulling up of the pile between each. Finally the number of blows when the hammer was separated from the pile and dropped, as when driving ordinary wooden piles, is entered. In the other columns are recorded the height of the drop, the depth of penetration into the ground, the character of the soil, and also the penetration under the various kinds of blows.

The table is also of interest in illustrating the penetration under blows of different height and different character.

It is noticeable in studying the times of the various units that the times of many of them, large for the first few piles, gradually decreased as the men became more expert in handling the work. For example, in the first pile driven, the time attaching ropes was 4 minutes, which near the end of the pile driving was reduced practically one half. The raising of the pile to place was reduced from thirteen minutes to about two minutes.

Methods Employed in Making Piles.

The method of construction is as follows; A 2-in. platform of rough plank is built on ground of sufficient area to hold all of the piles. On this platform chalk lines are struck and V strips to form a 1-in. chamfer nailed so that the lines of the piles are about 6 in. apart, alternating points and butts. The casting of the piles with tips and butts alternating is economical of space, but where the piles are cast so as to be handled directly by the pile driver, without any intermediate handling, it is best to cast them all with the butts toward the machine on account of the saving of time in getting the pile in the gins. Two 8-in. unplaned (to assist in skin friction) spruce planks form the sides of each pile. The piles are made in lots of about five. The outside form is cleated with 2 by 4's, and the other sides have the plank simply set on edge with pairs of wedges between them. There are seven cleats or wedges in the length,

and seven pieces 2 by 4 nailed across the top of each. After setting the plank sides, beveled pieces are nailed to locate the upper surface and form a chamfer.

Steel is wired together, as shown in Fig. 3, on a table consisting of plank on three horses. The reinforcement when made is suspended in form by two wires attached to each of the 2 by 4 cross pieces.

Fig. 4 shows a view of piles with the forms removed. Two days were usually allowed before striking the forms.

Gang making Piles.

One foreman		
2 laborers on miscellaneous work	@	$0.25
4 laborers wheeling and mixing concrete	@	0.25
2 laborers ramming	@	0.25
4 carpenters	@	0.43¾
4 steel men (2 carpenters and 2 laborers), averaging		0.40

The concrete gang mixed and placed concrete in 10 piles in 10 hours.

It took 4 carpenters 3¾ hours each, or a total time of 15 hours, to set up sides for 5 piles (10 sides), and 4 carpenters ½ hour each, or a total of 2 hours, to take down the sides for 5 piles.

It took one carpenter and one laborer 10 hours each to wire up 5 columns and place them in forms ready for concreting.

Each column was composed of four ⅞-in. rods in corners running full length of pile, ¼-in. hoops 12 in. on centers except for 2 ft. at the top, where hoops were spaced 4 in. on centers. Four additional ½-in. rods 2 ft. long and a ⅞-in. bent rod for hooking the pile were placed at this same end. A 1½-in. pipe was also placed in the center of the pile.

Mixing Concrete.

The concrete was mixed by hand in the proportion of 1 : 2 : 4, using ¾-in. trap rock, the sand and cement being first made into a mortar and the stone added. A thorough mix is of course essential. Mixing was started in March, precautions being taken at night against possible frost and the piles wet down every day for two weeks.

Age of Piles.

The age of the piles when driven ranged from 30 to 41 days, the larger part of them being nearer the shorter age. The first pile was molded on March 24 and driven on April 24, and during

this period the temperature was low, averaging between 40° and 50° fahr., so that the piles had not attained nearly their full strength. After the driving was commenced the weather became much warmer, and the piles after the first few were noticeably harder and entirely satisfactory, even although the age was practically the same, that is, about one month. The first pile driven lost its water pressure when about 6 ft. below the surface, and during the process of driving, which reached 700 blows, it is probable that it broke when about halfway down. The head of this pile was badly crushed, whereas subsequent piles which had hardened more thoroughly because of the higher temperature were uninjured, even with a similar number of blows and higher drops of the hammer.

It may be said, therefore, that a period of one month for seasoning piles is sufficient during, say, the months between May 1 and October 1, but during the colder months a longer period should be allowed unless artificial heat can be used to hasten hardening.

Pile Driver and Hammer.

It was decided, after a careful investigation of records of concrete pile driving both in this country and in Europe, to use a 4700-pound hammer. With a view to the use of the heavy hammer, and the side strains brought to bear on the machine by the dragging of the piles from the casting platform, a special driver was built. The driver was made as follows:

Long leaf hard pine was used throughout. The bed timbers were 8 by 10 in., 18 ft. in length, the gins 8 by 8 in., 42 ft. long. The braces of 8 by 8 in. timber were run from the bed timbers to the head of the machine with intermediate braces and ties to give the necessary rigidity. The sheave was of extra heavy pattern and the whole framework was bolted up and tied together with rods. The cushion head, which was perhaps the most essential item, as it was desired to avoid fracture of the pile from the blows of the 4700-pound hammer, consisted of a plate iron collar 16 in. square on the inside and 3 ft. in height, which incased an oak block 16 by 16 by 18 in., on to the bottom of which six thicknesses of rope and four layers of rubber belting were nailed. The cushion head was held in place in the gins of the machine by four perpendicular pieces of oak on the outside of the collar and bolted through the incased oak block.

A 25 h. p. Lambert engine was used and a single block for hoisting and churning the piles.

FIG. 5. PILE HOOKED AND BEING PULLED FROM PLATFORM.

FIG 6. PILE BEING PULLED TO PLACE (HAMMER DOWN TO STEADY MACHINE).

FIG. 7. EXTRA HANDLING OF PILE WHEN CAST WITH TIP TOWARD MACHINE.

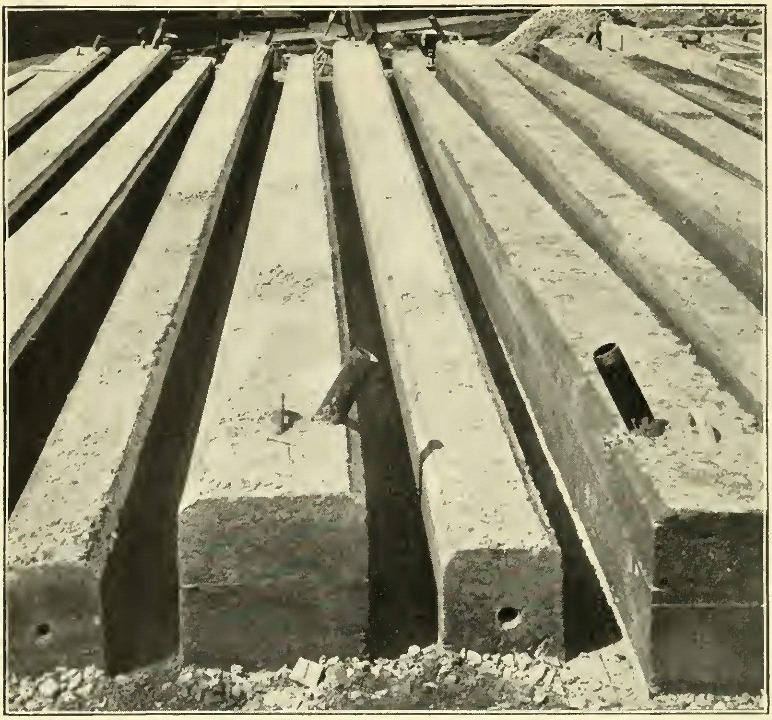

Fig. 4. View of Piles on Casting Platform.

Fig. 9. Butt End of Two Piles showing Hooking Ring and Pipe Connection for Jetting.

Fig. 11. Pile with Ends cut off Square, ready for Watertown Arsenal Test.

The water for jetting was furnished through a $2\frac{1}{2}$-in. Bay State hose, using a compound piston pump having 7-in. by 12-in. high pressure, and 12-in. by 12-in. low-pressure cylinders, and a capacity of 100 gallons per minute. This was the most unsatisfactory part of the entire work, the water pressure being variable and uncertain and 125 pounds the limit of pressure obtainable at the pump.

Driving Piles.

The usual process of driving consisted, after moving the pile driver, in hooking and dragging the pile, as shown in Figs. 5 and 6, and lifting it to place and attaching the hose, or attaching the hose first and then hoisting.

As already shown in Fig. 1, the casting of the piles with tips and butts alternating is economical of space, but where the piles are cast so as to be handled directly by the pile driver, without any intermediate handling, it is best to cast them all with the butts toward the machine on account of the saving of time in getting the pile into the gins of the machine. As seen in Figs. 5 and 6, when the pile is cast with the butt end toward the machine the pile can be lifted directly into the gins, while, in contrast to this, Fig. 7 shows that when the pile is cast with the tip end towards the machine it must be chained and dragged in front of the machine before it can be hooked in the usual manner and lifted to place.

Care must be taken when making the pile to place the hook for hoisting in relation to the projecting nozzle for jetting so that the hoisting rope will not foul the hose when the pile is being raised into position. To facilitate setting the pile into the gins, a crutch of 1-in. iron was made with a 12-in. by 12-in. square key at one end with a long handle to replace the peevy or cant dog ordinarily used for wood piles. As soon as the hose was attached, as shown in Fig. 8, and the pipe in place, the water was turned on and the pile usually penetrated for a short distance without the hammer. The hammer was then placed on the cushion and the pile sank further to a depth depending upon the nature of the fill. Next the hammer was attached to the pile with a chain and the churning commenced. There was enough play in the chain connection between the hammer and the pile to give about a 10-in. blow of the hammer each time the pile was lifted. When this churning became ineffective, the chain was disengaged and the pile was driven with blows in the usual manner.

TABLE A.
Data on Concrete Piles.

(1) Pile No.	(2) Date. Made.	(3) Date. Driven.	(4) Age at Driving.	(5) Dimensions at Point.	(6) Size of Pipe.	(7) Depth Driven. Ft.	(8) Moving Driver. Min.	(9) Placing Pile. Min.	(10) Time Driving. Min.	(11) Delays. Before Driving. Min. *	(12) Delays. During Driving. Min. †	(13) No. of Blows.	(14) Range in Drop. Ft.	(15) Last Blow. Drop. Ft.	(16) Last Blow. Penetration. Inches.
A	3-24-08	4-24-08	31	8″ x 8″	2″	18.0	spc.	109.5	191.4	58.0	87.5	697	1.0 to 4.0	5.5	$\frac{7}{8}$ ‡
B	,,	4-25-08	32	,,	,,	28.7	15.0	40.6	113.5	1.6	20.2	895	1.0 to 3.5	3.0	$\frac{1}{4}$
C	3-25-08	,,	31	,,	,,	25.6	11.1	46.8	41.7	0.0	12.0	280		1.0	$\frac{1}{8}$
D	,,	,,	31	,,	$1\frac{1}{4}$″	28.8	2.0	39.7	90.7	0.0	41.2	560	0.5 to 2.0	1.0	$\frac{1}{8}$
E	,,	,,	31	,,	,,	30.8	21.9	35.1	118.6	0.0	42.5	592	0.5 to 1.5	2.2	$\frac{3}{8}$
F	,,	4-27-08	33	,,	,,	30.9	← 104.5 →		28.1	1.6	2.5	187	0.5 to 5.0	4.0	$\frac{1}{4}$
I	3-26-08	,,	32	9″ x 9″	$1\frac{1}{2}$″	32.0	90.0	28.7	142.8	0.0	17.0	392	0.5 to 5.0	4.0	
J	,,	,,	32	,,	$1\frac{1}{4}$″	30.6	18.9	27.0	54.0	0.0	9.9	336	1.5 to 5.0	6.0	$\frac{1}{4}$
N	3-27-08	4-28-08	32	,,	2″ top, $1\frac{1}{2}$″ bot.	30.5	← 57.9 →		25.6	0.0	4.4	112	1.5 to 4.0	4.0	$\frac{1}{4}$
O	,,	,,	32	,,	1″	30.5	70.4	22.3	108.1	0.0	12.0	646	0.7 to 6.5	6.5	$\frac{1}{8}$
P	,,	,,	32	,,	,,	26.5	26.0	12.7	176.6	0.0	24.0	1 160	3.0 to 9.0	8.0	$\frac{1}{16}$
V	3-30-08	4-29-08	30	,,	$1\frac{1}{2}$″	31.0	50.0	15.3	69.2	4.6	6.8	509	1.5 to 5.5	5.5	$\frac{1}{8}$
W	,,	,,	30	,,	,,	30.5	5.0	15.1	128.8	0.0	12.6	939	0.7 to 6.0	6.0	$\frac{1}{8}$
X	,,	,,	30	,,	2″ to $1\frac{1}{2}$″	21.5	← 63.9 →		76.8	35.6	10.4	610	0.7 to 6.0	6.0	$\frac{1}{4}$ ‡
Y	,,	4-30-08	31	,,	$1\frac{1}{2}$″	30.5	← 69.5 →		32.1	0.0	3.0	255	1.5 to 5.0	5.0	$\frac{5}{8}$
Z	,,	,,	31	,,	,,	27.8	35.3	20.1	49.6	0.0	3.7	469	0.2 to 3.5	3.5	$\frac{1}{4}$
1	,,	,,	31	,,	,,	29.5	23.6	21.5	98.0	0.0	14.7	710	0.5 to 3.5	3.5	
2	,,	,,	31	,,	,,										
3	,,	5-1-08	32	,,	,,			35.0	42.0						
4	,,	,,	32	,,	,,		43.0	12.0	43.0						
5	,,	,,	32	,,	,,		40.0	10.0	36.0						
6	3-31-08	,,	31	,,	,,		← 29.0 →		60.0						
7	,,	,,	31	,,	,,		33.0	12.0	62.0						
8	,,	5-2-08	32	,,	,,										
9	,,	,,	32	,,	,,			45.0	75.0						
U	3-28-08	,,	34	,,	2″ to $1\frac{1}{2}$″		← 25.0 →		137.0						

* Included in Col. (9). † Included in Col. (10). ‡ Head smashing.

TABLE A.—Continued.
DATA ON CONCRETE PILES.

(1) Pile. No.	(2) Date. Made.	(3) Date. Driven.	(4) Age at Driving.	(5) Dimensions at Point.	(6) Size of Pipe.	(7) Depth Driven. Ft.	(8) Moving Driver. Min.	(9) Placing Pile. Min.	(10) Time Driving. Min.	(11) Delays. Before Driving. Min. *	(12) Delays. During Driving. Min. †	(13) No. of Blows.	(14) Range in Drop. Ft.	(15) Last Blow. Drop Ft.	(16) Last Blow. Penetration. Inches.
T	3-28-08	5-2-08	34	9″ x 9″	$1\frac{1}{2}$″		28.0	60.0	65.0						
S	,,	5-4-08	36	,,	,,		54.	.0	78.0						
R	,,	,,	36	,,	,,		30.0	15.0	115.0						
Q	,,	,,	36	,,	,,		25.0	10.0	55.0						
M	3-27-08	,,	37	,,	$1\frac{1}{4}$″		75.0	10.0	135.0						
H	3-26-08	,,	38	,,	,,		22.0	8.0	78.0						
G	,,	5-5-08	39	,,	1″		12.0	5.0	85.0						
K	3-27-08	,,	38	,,	,,		15.0	14.0	166.0						
10	3-31-08	,,	35	,,	$1\frac{1}{2}$″		105.0	15.0	50.0						
11	,,	,,	35	,,	,,		5.0	13.0	32.0						
12	4-1-08	,,	34	,,	,,		20.0	10.0	45.0						
13	,,	,,	34	,,	,,		20.0	10.0	52.0						
14	,,	,,	34	,,	,,		8.0	10.0	70.0						
15	,,	5-6-08	35	,,	,,		← 38	.0 →	112.0						
16	,,	,,	35	10″ x 10″	,,		5.0	10.0	75.0						
17	,,	,,	35	,,	,,	30.2	20.0	25.0	85.0	0.0	27.8	568	2.0 to 8.5	8.5	$\frac{3}{8}$
18	,,	,,	35	,,	,,	30.2	40.0	35.0	130.0	0.0	48.8	1018	2.5 to 20.0	10.0	$\frac{3}{8}$
19	,,	,,	35	,,	,,	30.3	40.0	15.0	110.0	0.0	15.4	740	1.0 to 6.5	6.5	$\frac{1}{4}$
20	,,	5-7-08	36	,,	1″			10.0	50.0						
21	4-2-08	,,	35	,,	$1\frac{1}{2}$″		10.0	10.0	75.0						
22	,,	,,	35	,,	,,		10.0	5.0	82.0						
L	3-27-08	,,	41	9″ x 9″	1″		28.0	20.0	190.0						
Av.			33.5				29.0	23.0	83.0	5.1	21.3	589			
Av.	during last 4 days.						27.0	13.0							
Av.	on 16 piles under 60 min.								44.0						

NOTE: Hammer weighs 4700 lb. Piles 14″ square at top. Water pressure low and variable. * Included in Col. (9). † Included in Col. (10).

crete and steel. It will, therefore, be seen that notwithstanding the severe treatment of the pile in driving, the ultimate strength was considerably higher than the average strength of similar columns. Evidently the strength of the pile was not appreciably affected by the driving or by the crushing of the head.

Cost.

The costs of the materials and the labor are tabulated in detail. The labor costs are taken from the time keeper's record, but are sufficiently subdivided to be useful for other jobs of a different character. The items which vary directly with the number of piles are separated from the costs which are independent of the number of piles but must be applied to any job as a constant expense. Only a few items depend upon the character of the ground.

The lumber for the forms (except the platform) is assumed to be a constant for any job, because it can be used over and over. The size of the platform must vary with the number of piles.

The pile driver for any one job is figured at 25 per cent. of the initial cost for depreciation and interest, but the cost of repairs is included in the items which vary with the number of piles.

The costs which are variable are given per linear ft. of pile for subsequent use. It will be seen that the total cost per linear ft. of pile on this particular job was about $1.63. If the length of piles differed greatly from those given, it might be necessary to still further separate the costs to provide for this.

A study of the various items taken in connection with a study of the detail times suggests various places where the cost may be altered for other jobs.

For example, an inspection of the costs shows that the cost of the reinforcing steel is over one third the cost of the piles. From the fact that the piles withstood the severe usage given by the pile driving, it is probable, if the piles are not over 30 ft. long, that $\frac{3}{4}$-in. steel instead of $\frac{7}{8}$ in. could be used for the corner rods, with extra reinforcement near the butt, as in the present case. The size of these rods can be determined by figuring the stress in them during the process of raising the pile to place. The pile is then a beam supported at the ends and carrying its own weight, which must at least be doubled to provide for swaying incident to the raising. The cost of the item of steel and labor would in such cases be varied accordingly.

The labor on concrete appears large, and might probably be reduced on another similar job from \$111.00 to about \$74.00. This is based on the fact that, while on the average only 6 piles were made, toward the latter part of the making 9 piles were made on one day and 10 piles on another, so that an average of 8 piles should be possible with the given gang. This is especially probable because the cost of making and placing the concrete was \$2.32 per pile, or \$2.25 per cu. yd., whereas the writer's data on hand mixing indicate that the cost should not have exceeded \$1.50 per yd.

With reference to the time and cost of the driving, it must be taken into consideration that the job was a small one, only 48 piles being needed; that the work was of an untried character, and also that the conditions were unfavorable, especially as regards the water pressure. On a large job, in ordinary ground, where large stones or obstructions are not likely to be encountered, the number of piles driven per day should be greatly increased. A study of the detail times in Table B at the end of the paper, and a comparison of these times with detail records taken on other jobs, indicate that the average time per pile driven with the aid of a water jet may be easily reduced to one hour, while if the ground is very soft, the average time per pile, including the moving of the driver, need not be over forty minutes. One hour per pile corresponds to 8 piles per eight-hour day, instead of 3½ piles per day. The estimated time on the items near the foot of the cost table, which is inversely proportional to the total number of piles given, would be decreased on a job having 200 piles from \$0.139 to \$0.035 per foot of pile. This, together with the reductions noted above, and the assumption of 8 piles driven per eight hours, would bring the estimated cost per linear foot down to \$1.00 net, or, with 25 per cent. allowance for pump hose connections, incidentals and profit, to \$1.25 per linear foot. In soft ground, and where conditions are specially favorable, a still lower estimate is possible.

Cost of Driving Piles on B. W. H. &. R. Company Job.

(See p. 1 and p. 16.)

	Total Costs.	Cost per Linear Foot of Pile.
(1) 6 000 ft. B. M. plank for platform @ $\$\frac{25}{4}$	\$37.50	\$0.0256
(Lumber cost \$25 per thousand and assumed to be used four times.)		
(2) 350 ft. B. M. for chamfer @ \$30	10.50	0.0072
(3) 25 lb. spikes for platform @ .03 } (4) 20 lb. 9d. @ .03 } (5) 8 lb. 4d. @ .04 }	1.67	0.0011
(6) 50 tons crushed stone @ \$1.50	75.00	0.0512
(7) $18\frac{1}{2}$ yd. sand @ \$1.00	18.50	0.0126
(8) $69\frac{1}{2}$ bbl. cement @ \$1.82	126.49	0.0864
(9) 192 pcs. $\frac{7}{8}$ in. by 30 corrugated bars, 15 333 lb., @ 2.65c	406.32	0.2670
(10) $34\frac{1}{4}$-in. bars by 48 piles by 5 ft. 0 in., 1 958 lb., @ 3.00c	58.74	0.0401
(11) 8 160 ft. No. 14 wire, $163\frac{1}{5}$ lb., @ $\$0.04\frac{1}{2}$	7.34	0.0050
(12) 4 pcs. $\frac{1}{2}$-in. bars by 48 piles by 2 ft. 6 in. = 480 ft. = 408 lb., @ \$2.85	11.62	0.0079
(13) 48 2-in. nipples, 12 in. long, @ \$0.15	7.20	0.0049
(14) 48 2-in. by $1\frac{1}{2}$ in. ells, @ \$0.12	5.76	0.0039
(15) 1 440 ft. g. i. pipe @ \$3.51 per 100	50.56	0.0346
(16) 48 hooks, @ \$0.25	12.00	0.0082
(17) Bending and placing reinforcement	122.62	0.0838
(18) Labor on pile platform	33.03	0.0226
(19) Labor on forms	83.72	0.0572
(20) Labor on concrete	111.07	0.0751
(21) Superintendence	31.20	0.0213
(22) Pile driving labor	399.42*	0.2722†
(23) Cutting slot in tip of pile	3.00	0.0020
(24) Repairs to pile driver and cushion	22.40	0.0152†
(25) Cutting off broken piles	23.51	0.0161†
(26) Rent of engine	30.00	0.0207
(27) Superintendence	42.00	0.0286†
Total cost	\$1 731.17	
Cost per ft. varying with number and length of piles,		\$1.1705
Items Constant for Each Job.		
(28) 2 800 ft. B. M. plank for pile sides @ $\frac{25}{4}$	\$17.50	
(29) 300 ft. B. M. plank for ends @ \$25	7.50	
(30) Pile driver 25% of \$198.21	49.55	
(31) Getting ready, 2 days, @ \$30	60.00	
(32) Teaming, pile driver, etc.	34.55	
(33) Removing driver	34.61	
Total cost per job	\$203.71	0.1391
Total estimated net cost per lin. ft. if job has 48 piles		\$1.3096
Add 25% for pumping, connections, contingencies and profit		.3274
		\$1.63

* After deducting \$60.00 assumed as constant "getting ready."
† Only items affected by character of ground.

A few of the items, such as the nipples and short bars, are constant per pile, that is, are independent of the length of the pile, so that in a close estimate for longer or shorter piles they should be separated out or allowed for by inspection.

As it assumed in the estimate in the last column that $5\frac{3}{4}$ piles are driven in 8 hours, the total cost for harder or softer ground can be estimated by assuming the number of piles to be driven per day and varying the items marked with a † accordingly.

Records of six of the typical piles are plotted and the curves are shown on the diagram which follows (Fig. 12) :

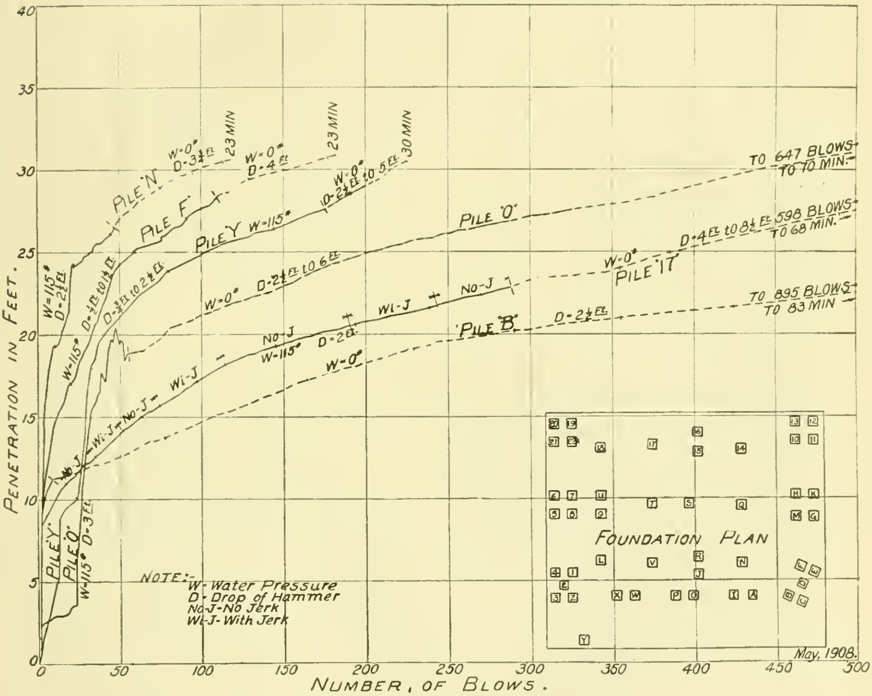

FIG. 12. TYPICAL PILE CURVES.

The full curves in Fig. 12 show the portion of the driving where the water pressure was on and the dotted lines the driving after it had been cut off by the filling of the pipe at the tip of the pile. This stoppage was not necessarily due to the design of the pile or to the method of driving, but chiefly to the insufficient capacity of the pump.

The flattening out of the curves indicates difficulties in driving, usually because of the poor water pressure. In certain

cases irregularities indicate the striking of obstructions, and when the pile is slightly jerked ground is lost instead of gained.

Curves of piles X, F and Y are given to show good driving, the pressure remaining on most of the time, and the total net time, omitting all unnecessary delays, being from 23 to 30 minutes.

Piles F and Y show also that if a greater drop of hammer had been used at the start they would probably have approached nearer to X.

In driving pile X, at 24-ft. depth the hammer was allowed to just tap the top of the pile with no impact; and the pile being slightly churned the loss of progress is shown by slight drop in curve. Then by increasing the height of the blow it started down again. Time, 23 minutes with 118 blows.

On pile F they first began jerking the pile after each blow, and this method appears to be effective provided ground is soft enough to actually lift pile readily. In hard ground it is ineffective. Drop of hammer was increased from 0.5 ft. to finally 4 ft. Time driving, 24 minutes with 185 blows.

Pile Y was not churned or lifted after first blow or two, but went down with light blows. Time, 30 minutes; 225 blows. Pressure good.

The curve of pile B is given to illustrate hard driving, due to lack of water pressure. The water pressure stopped at 11½ ft., as shown by the sudden break in curve at this point. Total time driving pile was 83 minutes with 895 blows.

In the curve of pile O there is an interesting break at the depth of about 20 ft. where an effort was made to assist the pile by churning or jerking, and ground was lost by doing so, and the pipe was also allowed to plug. As soon as the hammer was allowed to drop in the usual way the penetration began again, but 647 blows and 70 minutes by net time were required to carry it to its full depth. At a depth of 2½ ft. an obstruction was met, as indicated by the curve, and a small broken piece of timber came up beside the pile. Another reason for the flat curve of pile O is that the ground was usually hard.

Pile 17 was driven in an experimental fashion to determine the effect of the jerk at the end of each blow. The curve is uniform throughout, showing that this jerk is absolutely ineffective in hard ground. In this pile, as noticed, the height of drop was increased to 8½ ft. to see just what the effect would be upon the pile. It sustained this great impact without appreciable injury.

TABLE B.

DETAIL TIMES ON PILE DRIVING.

Getting Ready to Drive; Delays During Driving:

Pile No.	Date Made	Date Driven	Age at Driving, Days	Dimension at Point	Size of Pipe	Moving Machine, Min.	Attach Ropes, Min.	Pile Ready to Raise, Min.	Attach Hose and Ropes, Min.	Raise Pile Vert., Min.	Place Pile, Min.	Place Hammer, Min.	Delays: Time, Min.	Delays: Cause	Tanoing Machine: No. of Stops	Tanoing Machine: Time Av., Min.	Tanoing Machine: Time Total, Min.	Attaching Ropes: No. of Stops	Attaching Ropes: Time Av., Min.	Attaching Ropes: Time Total, Min.	Breaks in Hose: No. of Stops	Breaks in Hose: Time Av., Min.	Breaks in Hose: Time Total, Min.
A	3-24-08	4-24-08	31	8" x 8"	2"	Spc.	4	9	7.1	13.1	3.1	15	58	Fixing Cap.	8	3 3	26.5	1		1.60	5	7.2	35.8
B	3-24-08	4-25-08	32	8" x 8"	2"	15	2.3	17	4.2	7.3	7 5	0.7	1.6		4	0.5	2.2	0		0	0	0	0
C	3 25-08	4 25-08	31	8" x 8"	2"	11 1	3.5	12.2	6.0	←20	3 →	4 8	0		2	3.2	6.5	0		0	0	0	0
D	3-25-08	4-25-08	31	8" x 8"	1½"	2	5.5	15.9	3 3	←14.	4 →	†0.6	0		0	0	0	1 Take	off	1.25 rope	0	0	0
E	3 25-08	4 25-08	31	8" x 8"	1½"	21.9	6.0	10.9	5.0	2.8	9.5	0.9	0		3	0 8	2 5	0		0	1		31.0
F	3 25-08	4-27-08	33	8" x 8"	1½"	←	90.0	→	5.0	← 7.	9 →		1.6	Raise hammer and cap	0	0	0	1		2.55	0	0	0
I	3-26-08	4 27-08	32	9" x 9"	1½"	90	4.5	7.8	11.9	2.3	2.2		0		0	0	0	0		0	0	0	0
J	3-26-08	4-27-08	32	9" x 9"	1½"	18.95	5.9	7.7	2.0	← 9.	4 →	2.0	0		0	0	0	0		0	0	0	0
N	3 27-08	4-28-08	32	9" x 9"	2" to 1½"	←		53.	5 →	0.8	3 2	0.4	0		0	0	0	1		2.60	0	0	0
O	3-27-08	4-28-08	32	9" x 9"	1"	70 4	3.80	6.05	4 25	1.30	4 9		0		1		3.10	1		4.70	0	0	0
P	3-27-08	4-28-08	32	9" x 9"	1"	26.0	2 1	1.70	2.50	3.05	3.35	1.00	0		7	1.29	8.89	0		0	0		0
V	3-30-08	4-29-08	30	9" x 9"	1½"	50			3.40	4 50	2.80		4 60	Drive 6 x 6 and pull up	1	1.87	1.87	0		0	0		0
W	3-30-08	4-29-08	30	9" x 9"	1½"	5.0	1 80	3.30	4.60	← 5.	40 →		0		4	7.45	2.98	0		0	0		0
X	3-30-08	4 29-08	30	9" x 9"	2" to 1½"	• 20.	0 →		1.90	← 6.	00 →		11.10 24 50	Drive 6 x 6 and pull up. Pipe clogged	3	1.97	3 81	0		0	0		0
Z	3 30-08	4 30 08	29	9" x 9"	1½"	15.3	5.25	6.75	2.70	1.90	3.50		0		0		0	0		0	0		0
Y	3 30-08	4 30-08	31	9" x 9"	1½"	←—	66.0		—→	1.50	2.00		0	*	0		0	0		0	0		0
Av			33.5			32.2	3.8	8.2	4 2	3.3	4 3	3.2	5.1				5 3			0.7			3.5

Delays During Driving (Miscellaneous); Driving:

Pile No.	Miscellaneous: Description	Miscellaneous: Time, Min.	Number of Blows: No Hammer	Hammer Rests	Pile Attached: Short Blow	Pile Attached: Short Blow and Jerk Pile	Drop Hammer	Water Pressure	Net Time, Min.	Height of Drop of Hammer: Av., Ft.	Range, Ft.	Range, Ft.	Depth into Ground, Ft.	Character of Soil.*	Penetration: Av. per Blow, Ft.	Range per Blow, Ft.	Range per Blow, Ft.	Depths Driven, Ft.	Remarks.
A	Take off hose Place pads Place washes	5 5 5 4 12.7	1				695	60 60 *0	107.5	2.25	1	to 4	0 3.2 18.0	Fill Fill Sand	3.2 0.02	0	0.04	.05 3.20 14 80	No penetration with 1 ft drop
B	Connect hydrants 12 waits	7,90 9.93	1	1			858 35	60 60 *0 *0	3.30 1.90 83.00 5.00	2.5 3	1 —	to 3.5 —	— 9.5 27.0 28.7	Fill Fill & mud and lay	— 9.5 .02 0.025	0.02	0.03	— 9.5 17.5 1.7	
C	Time allowed between blows	5.50	1	1			278	0 115? 115?	— 29 7	1	—	—	— 10.2 16 6	Fill Fill & mud Sand	— 10.2 0.055	— 0.01	— 0.08	— 10.2 15.4	
D	Fix cushion Unnecessary work	32.5 11.8	10	1			549	? 115? 115?	1.85 47.70	1 5	0.5	to 2	0.44 5.24 28 84	Fill ,, Sand	0.44 4.40 0.043	— — 0.015	— — 0.20	0.44 4 80 23.60	
E	Take off hose Misc.	4 00 4 85	1 5 3 1 Slack	1			150 290 140	0 0 0 0 115? 115? 115? 0 0	0.5 3.3 1.1 18.7 38.0 15.0	1.25 1.5 2.25	0.5	to 1.5	2.5 4.0 5.2 5.5 8.0 11.9 22.1 28.5 30.8	Fill ,, Peat & mud do. do. Sand .. .. Clay	2.5 0.3 0.4 0.3 2.5 0.06 0.02 0.017	— — — — — 0.02 0.01 0.01	— — — — — — 0.10 0.04 0.025	2.50 1.50 1.20 0.30 2 50 3.90 10.20 6.40 2.30	
F		1.64	1	1	109 13		63	115? 115? 115? 115? 0	2.0 1.9 15.0 1.0 5.7	1.25 3 4	0.5 — 3	to 2.0 — to 5	1.9 9.1 28.5 30 9	Fill Fill & mud Sand Clay ..	1.90 9.20 0.19 0.06 0.038	— 0.0 — 0.02	— 0.04 — 0.04	1.90 7.20 19 40 — 2 40	
I	Remove broken piles Move machines Fix chain Misc.	8.00 2.20 4 30 2.60	1	1	31	58	74 227	115? 115? 115? 115? 0 0	1.5 1.3 10.9 5.0 9.1 115.0	0.7 0.25 1.00 4.5	0.5 0.08 — 4.00	to 1.0 to 0.5 — to 5.0	5.0 10.5 22.2 23.8 25.7 30.5 32.0	Fill Fill & mud Sand .. .. .. Clay	5.0 5.5 0.168 0.05 0.25 0.039	— — 0 05 0 0.02	— — 0.50 0.10 0 03	5 00 5.50 11.70 1.60 1.90 4 80 1 50	
J	Attach chain Take off chain Misc.	2.10 0.80 6.00	1	1		39	158 32 105	115? 115? 115? 115? 0 0	1.1 0.9 9.8 16.8 5.4 10.0	2.0 2.5 4.0 4 75	1.5 1.5 3.5 4.5	to 4 0 to 3.5 to 4 5 to 5.0	1.2 1.65 23.90 27 80 28.50 30.60	Fill .. Sand .. .. Clay	1.2 0 45 1.2 0.024 0.022 0.02	— — 0.5 0.01 0.02 0.02	1.7 0.05 0.04 0.03	1.20 0 45 22.25 3.90 0.70 3 10	
N	Take off hose Take off chain & rope Raise chain Misc.	1.35 0.45 1.89 0.75	1	1	43		3 64	115± 115± 115± 115± 0	0.70 0.95 13.60 0.30 5.70	2.5 2.75 3.5	1.5 — 3.0	to 3.0 — to 4.0	2.5 9 2 26.3 26.9 30 5	Fill Fill & mud Sand .. Clay	2.5 6.7 0.4 0.2 0.06	— — 0.00 — 0.05	— — 0.90 — 0.10	2 50 6.70 17.10 0.60 3.00	
O	Fix broken rope Take off hose Misc.	2.10 4.5 4.25	1 1	1		22 21 8	140 106 346	0 115± 115± 115± 115± 115± 115±	0.7 — 10.0 3.5 7 3 2.7 14.3 13.9 44.0	1.5 3.0 3.0 3.5 5.0 5.75	0.75 — — 2.5 5.0 5.5	to 2.00 — — to 5.0 to 5 5 to 6 5	2.0 2.4 8.0 10.4 18 5 24.5 27.2 30.5	Fill .. Sand .. .. .. Clay ..	2.0 0.4 0.25 0.60 0.043 0.025 0.010	— — — 0.00 0.10 0.02 0.02 0.005	— — 1.00 1.40 0.06 0.04 0.02	2.0 0 4 5.6 12.4 1.9 6.0 2.7 3.3	1 ft. drop; no penetration Old piece of timber 1¾" x 5" x 2½" washed up Pipe sprung leak
P	Misc.	14.98	1	1		19 5	1134	115± 115± 115± 0 0	0.60 35.00 5.05 1.65 110.40	2.50 2.00 6.00	— — 3.00	— — to 9.00	5.20 9.75 18.20 17 80 20.50	Fill .. Sand	0.42 0 0.007	0 -0 40 0	1.00 0.10 0.01	3.25 6.50 8 45 -0 40 8 70	
V	Misc. Place mats	1.97 4.95	1	1		16 7	140 185 152	115± 115± 115± 115± 115± 115± 0	0.60 5.90 5.38 2.00 21.70 20.00 19.80	2.5 2.5 3 25 3.50 5.50	2 — 1.5 — 4.0	to 2.5 to 3.5 — — to 5	2.4 10.5 18.85 18.30 23 80 27 85 31.00	Fill Fill & mud Sand .. .. Clay ..	2 4 8.1 0 55 -0.14 0.039 0.019 0.02	— — 0.10 -0.10 0.02 0.01 0.01	— — 2.30 -0.20 0.125 0.02 0.025	2 4 8.1 8.35 -0.55 5.50 4.05 3.15	
W	Misc Take off hose	4.10 5.50	1	1		22 41 8	866	115± 115± 115± 115± 0 0	0.50 3.90 6.80 4.10 104 40	0.75 1.50 [1]2.00 [2]0.50 4.00	0.50 0.75 3 00	to 1.00 to 2.00 to 6.00	1.20 2.20 4.00 18.20 17.50 30.50	Fill .. Sand & mud Sand .. Clay	1.20 1 00 0 13 [4]0.44 -0.09 0.015	0 0.05 0.20 0.01	0.60 5.25 0.00 0.02	1.2 1.0 18 20 -0.70 13.00	Owing to some obstruction pile was pulled out and started over again Special case
X	Take off chain Place pads	1.10 3.27	1	1		159 15	434	115? 115? 60 0 0	0.90 4 10 19.60 1.10 39 30	1.00 1 00 4.00	0.75 — 2.50	to 1.00 — to 6.00	1.50 2.40 18.75 .. 21.50	Fill .. Sand	1.50 0.90 0.10 -0.05 0.0076	— — 0.00 — 0	— — 0.25 — 0.02	1 50 0.90 15 85 3 25	
Z		3.7	1	1		198 117	22 130	115± 115± 115± 115± 115± 115± 0	1.20 22.80 9.90 1.35 10.70	[2]0.25 3.50	0.16 2 00	to 0.50 to 3.50	1.00 6.75 22.30 25.75 26.00 27 80	Fill Mud Sand lay ..	1.00 5 25 0 09 0 01	— 0 0.002	— 0.15 0.15	1 00 5.75 15 55 3.45 0 85 1 70	
Y	Take off chain Take off hose	1 30 1 68	1	1		166 7	25 75	115± 115± 115± 115± 0	0.7c 1.9c 19.88 0.52 1.87 4.20	[1]1.50 [2]0.50 Do. 2.50 5.00			0.80 1.50 27.30 27.60 29.00 30.50	Fill Sand Clay	0 80 0.70 0 155 0 06 0.06 0 06	0 0	— 0.25 0.12	0 80 0 70 25 80 0.30 1 40 1 50	
Av		12.5							64.0										

* Pump working at 60 lb. pressure, but no water running through pile.
In piles A, B, C, D, E, the hose was attached after pile is set in machine; rest of pile hose is attached before raising.
† Pile was raised and lowered ten times before hammer was placed.

[1] Hammer. [2] Pile. [3] Pull pile. [4] Special.

NOTE.—0.01 ft. is approximately equal to ⅛ in.

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In one other pile not shown on the diagram the drop reached 12 ft. The head was slightly smashed with this severe treatment, but no rods were exposed. During the driving of this pile different heights of drop were used, varying generally from 2½ to 4 ft., and greater penetration is shown with the 4 ft. drop. The average drop for this pile was 5 ft., but as the water pressure stopped when about one-half way down it required 1 000 blows and 160 minutes to drive it.

DISCUSSION.

MR. L. S. COWLES. — In one of the views shown, where one pile was so badly battered, there appear to be two piles excessively close together. Were those driven the full depth?

MR. FOX. — They were about 2 ft. 6 in. on centers in bunches of four. We figured 100 tons load per pier and four concrete piles to carry the load.

THE PRESIDENT. — I should like to ask Mr. Fox if he can tell us the nature of the ground there, and what the piles encountered at the bottom.

MR. FOX. — From the surface to from 6 to 8 ft. down, ordinary filling, through which the pile went readily, partly by its own weight; from this down to from 29 ft. 7 in. to 31 ft. 6 in. below the surface it was practically all sand, with a very little peat and mud, and below that there was hard pan 13 ft. thick of clay. We anticipated hard driving, as there were some oak piles driven for a bulkhead within 50 ft. of this location and the best that could be done was seven piles a day.

MR. H. F. BRYANT. — What is the water level in relation to these piles?

MR. FOX. — The water is about six feet below the surface.

THE PRESIDENT. — I would ask, in regard to the sample tested at the Watertown Arsenal, whether the longitudinal rods went to the extreme ends of the sample, or whether they were covered with concrete.

MR. FOX. — We simply squared off the top and bottom of the concrete pile, cutting off the rods flush with the surface. At the Arsenal before testing the ends were trued with a thin layer of neat cement.

THE PRESIDENT. — Mr. Thompson spoke of its being possible to reduce the size of the reinforcing rods, and said that we have only to figure tensional stresses in raising the pile. I would like to ask whether there is not some value of the steel in compression in piling.

Mr. Thompson. — Yes, I certainly should not drive any pile without reinforcement, but from the way the piles acted in driving, the amount of steel for other than structural purposes would seem to be a matter of judgment rather than of computation. In my judgment the steel, except near the top of the pile, might be reduced somewhat. I should not in any case use smaller than $\frac{3}{4}$-in. rods.

Mr. Wm. Parker. — I should like to ask what it was that determined the length of the pile driven.

Mr. Fox. — We took soundings to hard pan at the level of 31 ft. 6 in. below the surface.

Mr. G. T. Sampson. — I did not gather from what was said of this work in Cambridge whether any formula was used for determining the sustaining power of the pile, or whether or not there was a specified length of pile required. May I ask what the load was?

Mr. Fox. — Twenty-five tons. I think, perhaps, Mr. Thompson will answer in regard to the formula.

Mr. Thompson. — I took the formulas for concrete piles and found them to vary so much that it was absolutely impossible to get anything from them. Of course in this particular class of work the pile is very similar to a wooden pile, and it is a question whether the wooden pile formula would not apply fairly well. The load taken for the pile was based rather on precedent and tests made in other places, together with a review of the results obtained by a computation from a number of formulas.

Mr. Parker. — The purpose of my question was to lead up to another of considerable interest, but Mr. Fox's reply developed the fact that soundings were taken presumably by a steel rod, showing that there was a hard pan beneath the soft material. If we were to drive into what we call Boston clay, which is of very great depth in many parts of the city, a sounding rod or a water jet could be put down almost to an indefinite depth, and it would be hard to tell how long a pile should be made. In this particular case, with the hard pan or under stratum, it seemed to be a sure thing that you would get a satisfactory footing for your pile. But in the case of the clay bed, through which the sounding rod or the pile might be driven indefinitely, it would seem that a formula would be necessary to determine something of what would be a safe load. It runs in my mind that other methods would have to be adopted in a clay-bed foundation, which is, I think, in the majority of cases, the kind of foundation we have in Boston.

Mr. Thompson. — I would say in this connection that the penetration was recorded under the last blow of the hammer, and the average penetration at this last blow, except in a few cases, ran about $\frac{1}{8}$ to $\frac{1}{4}$ in., with a drop of 4 to 6 ft., and figuring it by the *Engineering News* formula it comes out very nearly 25 tons safe load.

Mr. J. P. Snow. — I should like to know what determined the diameter of your pile at the top, and whether, if you had a heavier load to carry you would consider a larger pile more effective than the 14-in. pile you have described.

Mr. Fox. — The size of the pile, I think, would be determined more by looking back through the records than by figuring. If we had had a heavier load to sustain we should certainly have made the piles larger, both at the top and at the bottom.

Mr. Cowles. — I should like to ask whether any estimate has been made as to the increased cost of this method of supporting 100 tons over the wooden pile foundation, with such additional concrete base as would be necessitated.

Mr. Fox. — It was found cheaper by our estimates to use concrete piles than to use wooden piles, and the actual cost which Mr. Thompson gave you agrees substantially with the estimated cost.

Mr. Sampson. — May I ask how near together these piles were placed? It appears as if they were almost touching each other.

Mr. Fox. — Two ft. 6 in. on centers, in clusters of four.

[Note.—Discussion of this paper is invited, to be received by Fred Brooks, Secretary, 31 Milk Street, Boston, by April 15, 1909, for publication in a subsequent number of the Journal.]

CONCRETE PILES USED IN THE STEAMSHIP TERMINALS AT BRUNSWICK, GA., AND IN NAVY YARD PIER AT CHARLESTON, S. C.

By M. M. Cannon, Member American Society of Civil Engineers.

[Presented to the Boston Society of Civil Engineers, September 16, 1908.]

The work about which I am invited to talk informally was at the steamship terminals, constructed for the Atlanta, Birmingham & Atlantic Railroad, at Brunswick, Ga., and at the pier built for the government at Charleston, S. C., and I am to speak particularly of the concrete piles used in their construction.

In January, 1906, the Fore River Shipbuilding Company was commissioned by the Atlanta, Birmingham & Atlantic Railroad to design and construct a steamship terminal at the end of the railroad in Brunswick, Ga. Brunswick is a small town of about 12 000 or 13 000 people, about half of whom are negroes, situated on the Atlantic coast, about half way between Jacksonville and Savannah. It has an excellent harbor; I think, in fact, one of the best on the South Atlantic coast; but the waters there are infested with the teredo to a very great extent; so much so that untreated pine piles are of no value after about two years' time. The first proposition that we encountered was to determine upon a type of construction that would be economical and permanent, and after much investigation it was decided to use reinforced concrete piles.

I made two reinforced concrete piles at the Fore River Shipbuilding Company's plant in Quincy and conducted a number of experiments with them. They were 14 in. sq., one about 45 ft. long and the other about 20 ft. The wooden form in which the piles were molded had two sides to it, the top being open. The proportion of cement, sand and stone in the concrete was 1 : 2 : 4. Four reinforcing bars of round, soft steel extended the full length of the pile, with hoop reinforcement of $\frac{1}{4}$ in. round steel clips placed 12 in. apart on centers. The piles were 14 in. sq. to within 10 ft. of the bottom, the last 10 ft. being drawn in until they were 8 in. sq. at the bottom. They had a $1\frac{1}{2}$-in. diam. water jet extending almost the entire length, or to within about 2 ft. of the top.

The concrete was poured into the forms and kept sprinkled for about seven days and not moved or disturbed for at least three weeks after the piles were cast. At the end of that time the piles were picked up by means of a locomotive crane and taken to the shore at Weymouth Fore River, the bottom there being sandy and having coarse gravel in it. The longer pile was driven between high and low water mark by means of the water jet and hammer until it had penetrated 18 ft. into the bottom and allowed to remain there until the tide went out. In the meantime we drove the small pile twice, once by means of the water jet and the second time without the water jet. The second time the head of the pile was pretty badly shattered by the hammer. We also drove an oak pile about 15 in. in diameter at the top and, where it went into the ground, about 10 or 11 in. in diameter. It was driven within 5 ft. of the concrete pile. After the tide went out an attempt was made to pull the concrete pile over or break it. A chain was fastened about 8 ft. above the ground and to that two double blocks and a 4-in. line were attached. One block was fastened to an adjacent pier and the free end of the tackle taken to the gypsy head of a pile driver engine, four turns being taken around the gypsy head, one man holding it and 80 lb. of steam on the boiler. Ten or twelve attempts were made to pull the pile over but were not successful. Four more turns of fall around the second gypsy head of engine were necessary to break the pile on the fourth attempt. The oak pile was then broken on the first attempt under exactly the same conditions.

Afterward, in observing the reinforcement of the broken concrete pile, which consisted of four bars about 2 in. from the outside surface of the pile, we found that in putting the tackle on the pile, instead of getting it at right angles to one face, we got it so that it pulled diagonally on the pile, and the rod that broke was the rod on the back corner. It broke right at the ground, the other rods bending over. Unfortunately, the rods were welded and the weld in the broken rod came right at the ground. Subsequent examination showed that not more than 50 per cent. of this weld had caught. If we had placed the tackle at right angles instead of diagonally I do not believe we should have broken it.

With this information at hand we proceeded to design the terminals at Brunswick, actually starting construction July 5, 1906. The land on which they were located was a piece of marsh 200 acres in extent, filled in by means of hydraulic dredges.

The terminals consisted of two piers, one 500 ft. long and 140 ft. wide, the other 900 ft. long and 140 ft. wide, with a coal trestle and a coal pier about 300 ft. in length and a basin 1 700 ft. long and 250 ft. wide. At the head of each pier were two warehouses 400 ft. in length and 80 ft. in width; there was also a power house 125 by 40 ft. Underneath the piers the concrete piles were used for the bearing piles entirely. They were driven on 12-ft. centers both crosswise and lengthwise of piers. The piles used under the terminals ranged from 30 to 51 ft. in length and weighed from three to five tons each. The reinforcement was practically the same as that used in the test pile at Fore River, except that we used four $1\frac{1}{4}$-in. bars. At the head of the pile Clinton electric welded reinforcement came down about 4 ft. It was placed there to help stand the shock from hammering. A $1\frac{1}{2}$-in. water jet was used. The piles were 16 in. sq. to within 10 ft. of the bottom and 8 in. sq. at the bottom. They had a 4-in. shoulder 16 in. from the head cast on two opposite sides that left a tenon at the head of the pile 8 by 16 in. The forms were made in one piece the entire length of the pile, the corners being beveled 1 in. The concrete was mixed in the proportions of one part cement, two parts sand and three parts broken stone and mixed very wet. In fact, the rule we observed for the amount of water in concrete was determined entirely by the distance the concrete was carried in wheelbarrows, the mortar being kept just moist enough so that the stone would not settle to the bottom of the wheelbarrow. At first stone from 1 in. down was used. The concrete was made in a mixer and wheeled in barrows to the forms. Great care was used in tamping, as many as seven men being used to each pile, and the casting of each pile was made one continuous operation. After the piles were made the forms were removed in twenty-four hours. They were then kept moist for seven days, at the end of which time they were picked up by means of a traveler and chain bridle and moved to the storage place, where they were kept for two weeks longer. At the end of that time they were taken to the floating pile drivers and driven. When the first piles were driven we endeavored to pursue the same course as had been followed at Fore River in the experiments. A cast steel cap, sliding in the leads of the pile driver with a 4 500-lb. hammer was used in the driving of the piles. In the bottom of the cap was placed some rope and rubber and in the upper part a wooden block which the hammer struck. The cap was made to fit over the top of the tenon in the pile. It kept the pile from turning, so that in driv-

ing it could not get out of position, a very important thing, for it was necessary in this work to get the piles in exact position and keep them there. The first week we attempted to drive them by means of the water jet and hammer, but succeeded in gett ng down only 4, 5 and 6 piles a day. In fact, I don't know that we got down as many as six. The driving was particularly long. The piles were 51 ft. long and fully 40 ft. of them were driven in the ground. We were rather discouraged that it took so long to drive the piles and decided to try some other method, finally deciding on the scheme of raising and dropping them. A wire bridle was fastened around the top of the pile, by which to lift it, the hammer and cap being allowed to remain on the top of the pile as an additional weight. The piles were raised from 18 in. to 2 ft. and dropped By this method we increased the driving until some days I have seen as many as 27 to 30 piles driven in fourteen hours. The piles averaged from 30 to 51 ft. in length. On account of the water jet boring a hole ahead of the pile, it was found necessary in driving to shut off the jet and drive the last few inches by means of the hammer, the distance to be determined by experience according to the character of the bottom we were driving in. If we had good clear sand, we used to shut off the jet and drive the last 8 or 10 in. with the hammer without any jet, the hammer dropping from 6 to 8 ft. The man running the level could determine very easily after he had become accustomed to it when to begin driving with the hammer.

The character of the bottom in the Brunswick work varied considerably. We had good clear sand, clay as hard as any here in Boston and some the hardest I have ever seen. Also we had to drive through a stratum of soft rock composed of shell, sand and lime which was harder than any coral, and have driven many reinforced concrete piles through 2 ft. of it. Afterward we pulled some piles up that had been driven through this material and found the edges of bottom of pile just slightly rounded off. There were about 6 000 piles driven and about 50 per cent. of them through the above material.

At the head of the piers we drove a bulkhead of 6 by 14 in. reinforced concrete sheet piling. The piles had four reinforcing bars and one side of the bottom was beveled off the same as with wooden sheet piling to keep them together. We used no water jet on the inside of these piles, but on the outside, and in that way saved considerable pipe.

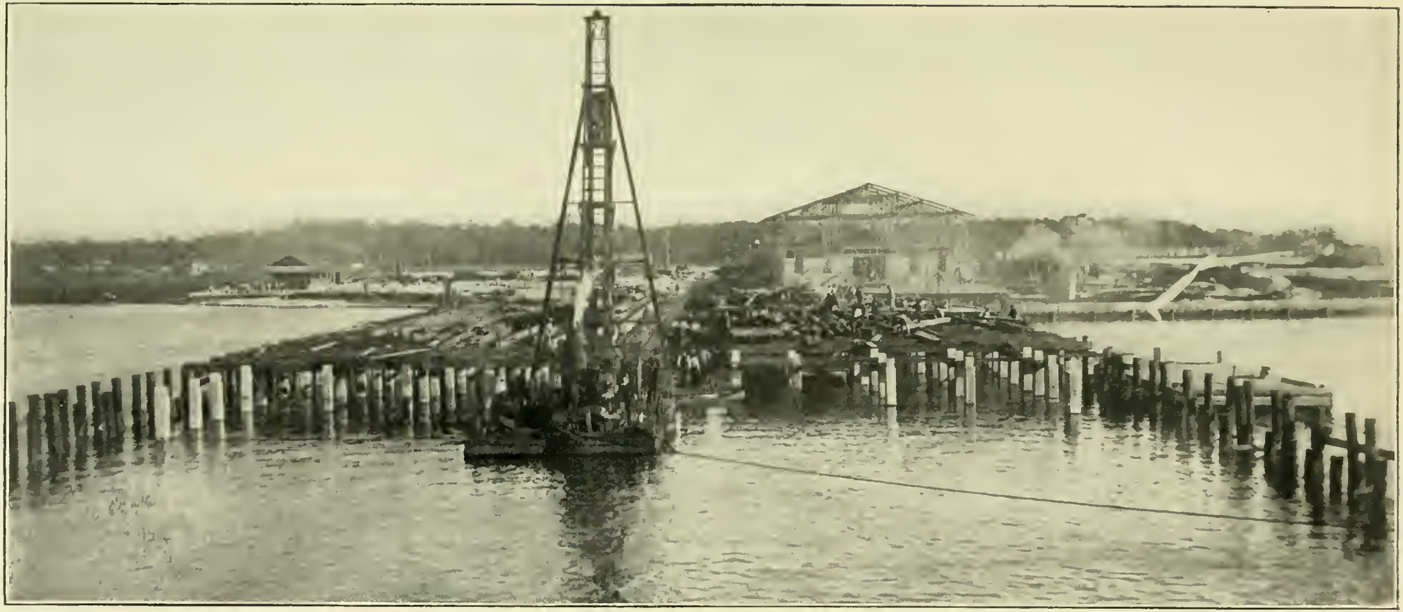
There is one thing I have overlooked in speaking of the jet for concrete piles. The $1\frac{1}{2}$-in. pipe was carried only one third the

length of the pile, coming out of the pile at the ground level in the shape of a reversed curve. We then used a separate piece of pipe on the pile driver long enough to extend down and to fit into the other pipe where it came out of the pile. That upper piece was taken out and used over again, the object being to save pipe, and we were able by this means to save from 25 to 30 ft. on each pile. We also found it feasible to use a jet the same size the entire length of the pile. A $1\frac{1}{2}$-in. jet was used on the first pile we drove at Brunswick, and I tried putting a small end on it, but in every case we were able to drive the pile into position with a straight jet and do it quicker than we could with the jet reduced at the bottom. Out of all the 6 000 piles we drove I don't think I can remember more than one or two instances where the pipe clogged from driving. The jet seemed to be successful in keeping it open. And as I have previously stated, we have driven in sand and clay and the hardest kind of bottom and never had any trouble.

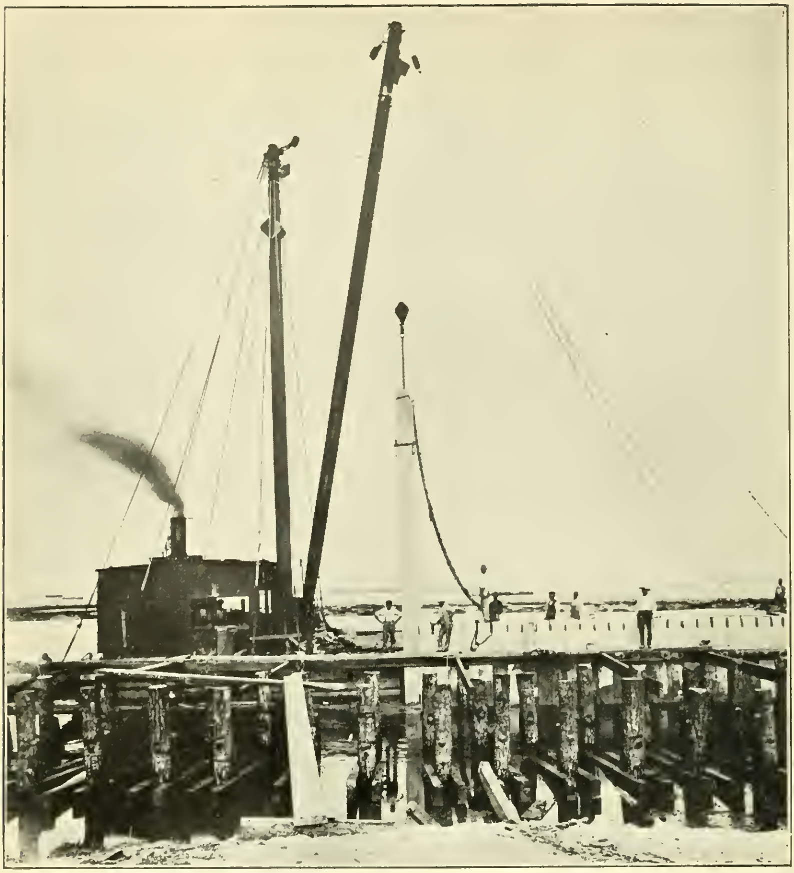
The sheet piling was of the same mixture of concrete as used in bearing piles, the proportions being one, two and three, with stone of 1 in. in size. We filled in behind the bulkhead to a height of 12 ft. I do not deem it advisable from the experience I had, to use 6-in. sheet piling, and would not advise any less than 8-in. in thickness. The shoulder and groove are so light on the 6-in. piling that it is difficult to keep the shoulders from breaking, while with 8 in. the joints were perfect.

Under the power house we drove some concrete piles; in fact, the entire building is supported on them, 14 in. sq. and 25 ft. long, with the same reinforcement as we used for the piers. But this method was abandoned afterward on the other work, for the reason that it was found we could drive pine piles, cut them off at the water level and put concrete piles on top of them cheaper than we could drive concrete piles.

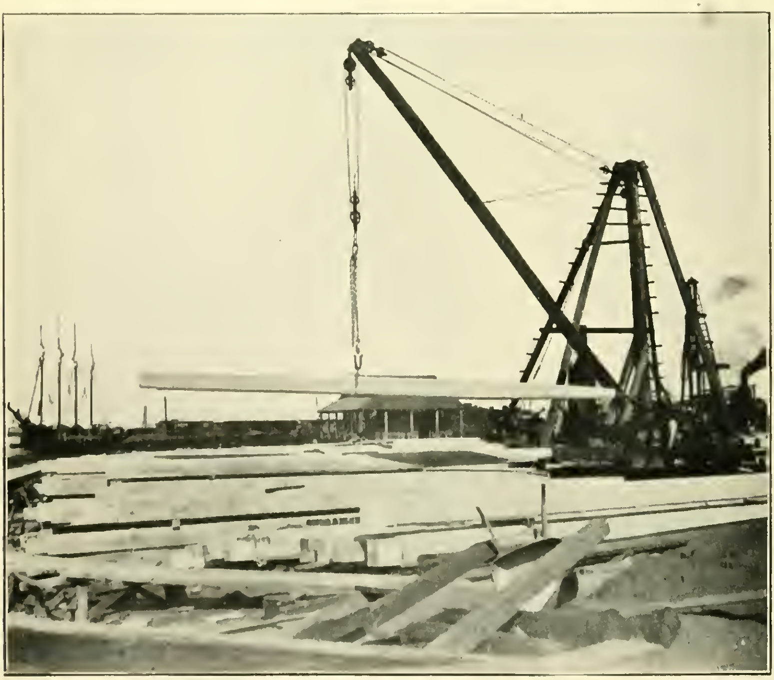
We had several severe tests of concrete piles on these piers. One of the steamers running on this line (they are boats of about 1 800 tons net and carry 3 000 tons of freight) came into the harbor on her maiden trip. It was the first steamer to arrive and came before the outer end of the first pier was finished. In order to bring this steamer to her berth a 9-in. hawser was fastened around the tenon of one unsupported concrete pile, about 32 ft. of which was above the ground level. The tide runs at this location exceedingly fast and the one pile successfully withstood the test of pulling this vessel against a rapid running tide to the pier. At another time one of the steamers ran into



Pier for Atlanta, Birmingham & Atlantic Railroad, Brunswick, Ga. [Completed Dimensions, 140 ft. by 900 ft.



Driving Reinforced Concrete Sheet Piles, 18 in. by 18 in. by 41 ft., long, Brunswick, Ga.



Handling Reinforced Concrete Pile, 16 in. by 16 in. by 51 ft., Brunswick, Ga.

the pier owing to misunderstanding of signals in the engine room and broke a number of pine piles, but the concrete ones successfully withstood the shock.

I have seen rails piled on deck of pier that brought a load of 60 tons on each of 6 piles with no settlement whatever; also lumber that caused a load of 40 tons per pile.

The basin previously mentioned is 1 700 ft. long by 250 ft. wide. The construction in that is perhaps unique and more interesting than the concrete bearing piles.

We built a bulkhead with concrete sheet piles, 18 in. sq. and 45 ft. long and weighing 7 tons apiece. Pine piles were driven and a platform built on them on which the concrete piles were made. At the end the piles were beveled off to 12 by 18 in. The reinforcement of these piles consisted of four $\frac{3}{4}$-in. corrugated bars running the entire length of the pile. For the lower two thirds of the pile, that part from low-water mark down to the end, two $1\frac{1}{4}$-in. corrugated bars were put in to form a truss to take the strain where the maximum load came on the pile. We used a 2-in. water jet instead of a $1\frac{1}{2}$-in. and found it much preferable. These piles had a tongue and groove on them. The proportions of concrete were 1: 2: 3, the same as in the other work. This work was done by Mr. W. L. Miller, of Boston.

The piles were made on the platform of which I have spoken, 20 of them being cast in a day. They were allowed to set and kept moist seven days, at the end of which time they were picked up by means of a lighter, carried away to the storage pile and allowed to remain three weeks longer before being driven. The joints between the piles fitted very close, in fact much better than wooden sheeting. The bottom through which the piles were driven varied, I think, more than in the case of the other piles. Sometimes it was sand, then again very hard blue clay. In the case of these piles we drove them the entire way by churning, not using any hammer at all.

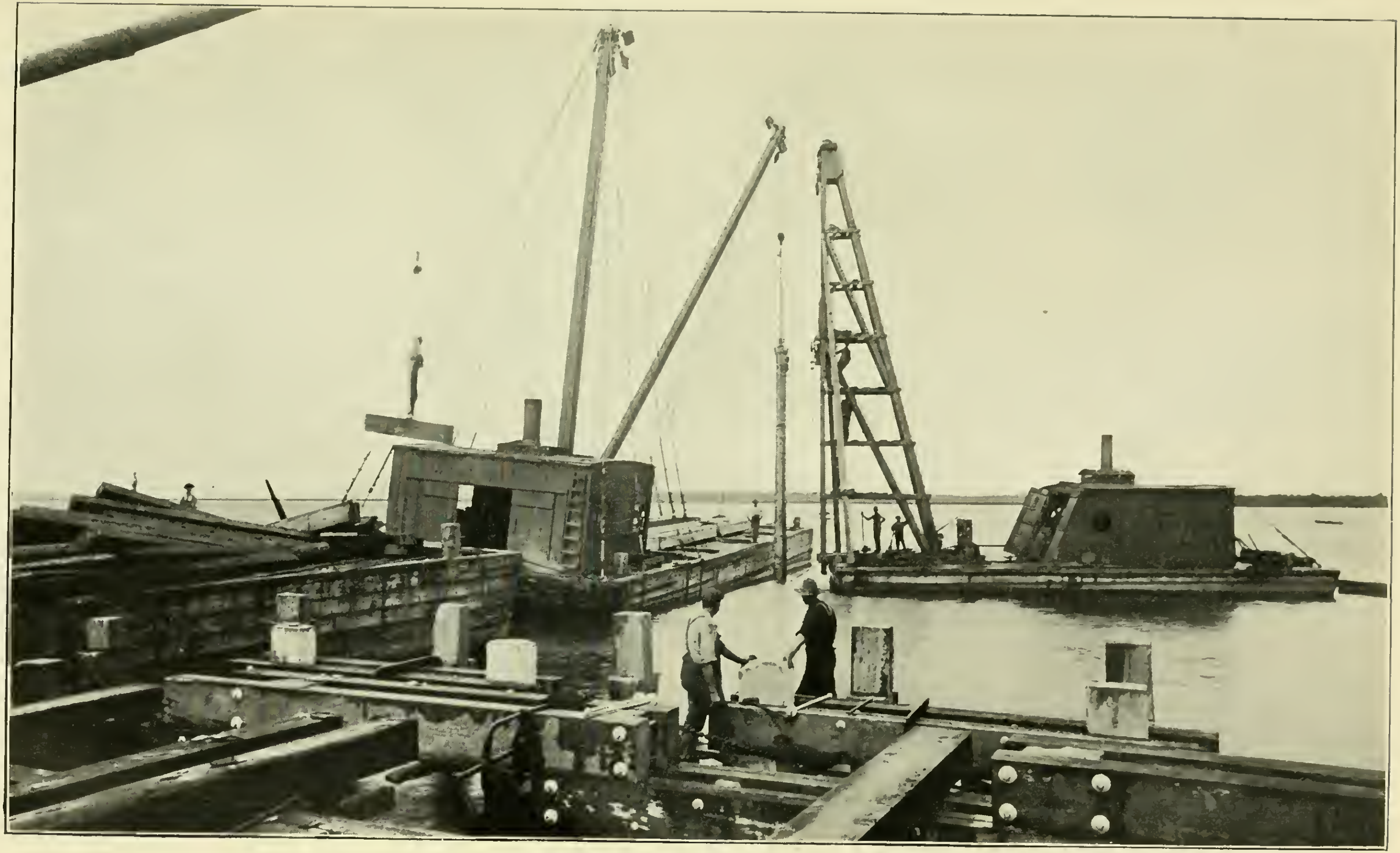
The anchorage consisted of two double rows of plain yellow pine piles from 35 to 40 ft. long, the first row 25 ft. from the bulkhead and the second row 15 ft. further back than that. Also in front of these piles dead men were placed and the front row was connected with the concrete sheet piling by $2\frac{1}{2}$-in. rods in every other concrete pile. On the front of the sheet piling we constructed a concrete wale 12 in. wide and 16 in. deep, in which heads of rods were imbedded. Two 1-in. corrugated bars were placed in it for reinforcement. After the rods had been placed and the concrete wale thoroughly

set, the nuts on the anchor rods were set up as tight as possible and the filling deposited back of the bulkhead. After the filling had been completed (the bulkhead being 3 700 ft. long) we examined the concrete wale; in fact, it was examined more or less often for fully three months afterward, and we never found a crack in it, which seems to show positively that the bulkhead has never moved. I believe if it had moved it would have shown in the cracking of the wale before any other place. It seems to be the general opinion of everybody connected with the work, and of everybody who has been there to examine the work, that the basin was the best construction we attempted. The filling in behind the bulkhead, of course, gives an admirable foundation for the erection of warehouses, and reduces maintenance to a minimum.

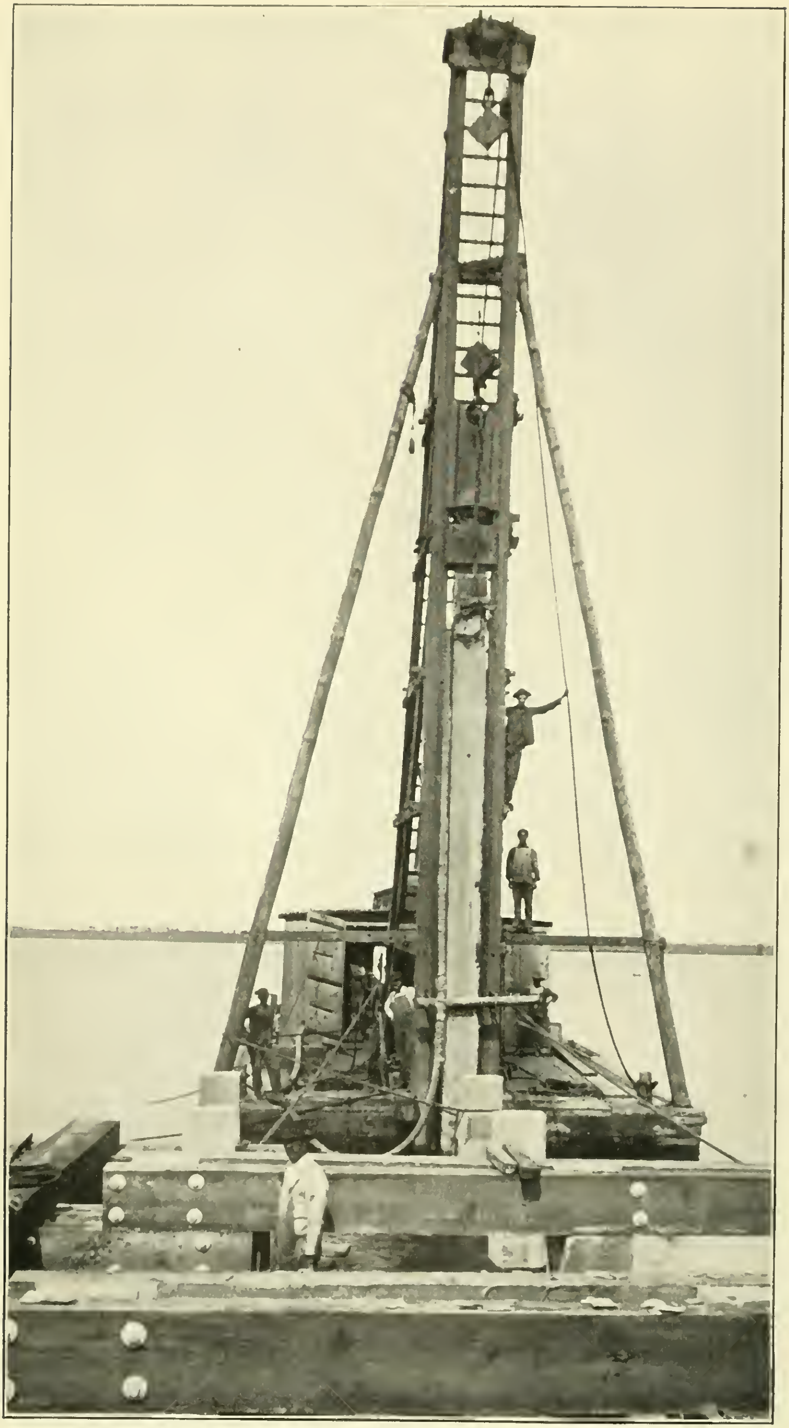
The number of piles driven on the Brunswick work was 5 426. The approximate cost of the terminals was $1 500 000. The two piers built cost about $1.40 per sq. ft., that is, figured on the surface of the dock. The cost of the 18-in. bulkhead was $75 per running foot complete, exclusive of the dredging. The work started July 5, 1906, and was completed May 1, 1907, or in eleven months. Mr. Miller built the basin, starting the first of May and completing it the first of November, six months.

We will now take up the pier at Charleston. This pier was designed for the Charleston navy yard at Charleston, S. C., and is 60 ft. wide and 520 ft. long. It is built upon cast reinforced concrete piles of the same general design as those used in the Brunswick work. They are 55 ft. long and 18 in. sq. to within 8 ft. of the bottom and then taper off to 12 in. sq. The reinforcement of these piles consists of four $1\frac{1}{4}$-in. twisted bars and two $\frac{7}{8}$-in. bars. The government asked the contractors to submit their own design for concrete piling, the cross-sections of which should be equal to 18 in. sq. and 7 sq. in. of reinforcement, and we could get the best arrangement of the reinforcement by the use of the rods I have mentioned. The $1\frac{1}{4}$-in. bars are placed in the corners of the pile, $2\frac{1}{2}$ in. in from the outside. The two $\frac{7}{8}$-in. bars were put in the pile $2\frac{1}{2}$ in. in from the surface on opposite sides and on a line across the pier.

These piles were made on the same general scheme as the sheet piling at Brunswick. They were built on a platform, wooden forms were used, a 2-in. water jet 22 ft. long was put into the pile and for the rest of the distance was outside. The piles were kept moist seven days and then picked up by means of a lighter and carried away to the storage pile. The scheme used

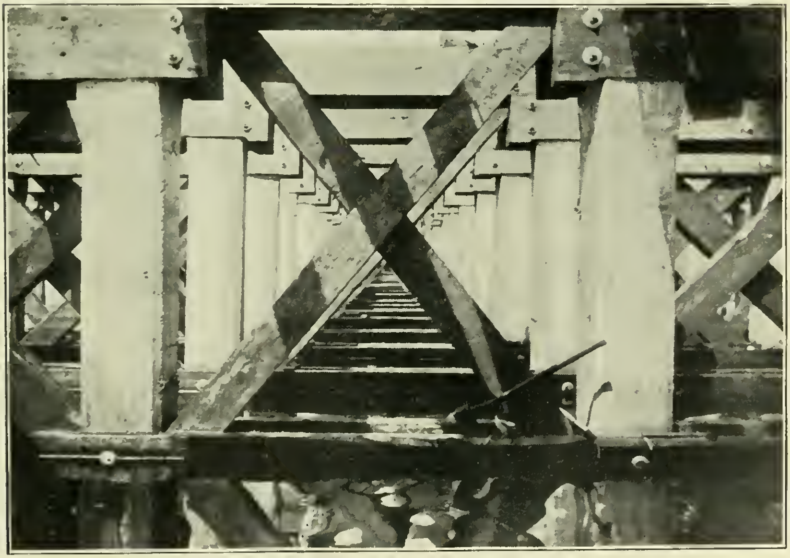


Pier at United States Navy Yard, Charleston, S. C., showing Method of Handling Piles.



Driving Reinforced Concrete Pile, 18 in. by 18 in. by 55 ft. long, at Pier at United States Navy Yard, Charleston, S. C.

Driving Reinforced Concrete Piles to Grade. Pier at United States Navy Yard, Charleston, S. C.



Pier at United States Navy Yard, Charleston, S. C., showing Method of Bracing.

Pier at United States Navy Yard, Charleston, S. C., showing Capping and Method of Bolting to Pile.

for lifting these piles, which weighed 10 tons each, was to use a bridle, consisting of two chains kept apart by a piece of yellow pine 18 ft. long. Hanging down from each end of this piece of timber were two big timber hooks. These were used to lift the concrete piles. We had no trouble in lifting them. In fact, of all the piles driven at Brunswick or at Charleston, I never saw one broken from lifting it. We carried them from the storage pile to the site where the work was being done on lighters. (See illustrations.)

The scheme of superstructure of this pier was practically the same as in the Brunswick work, except that it was heavier. The shoulders on each side of tenon for supporting the girder caps were 8 in. in place of 4 in. as at Brunswick, and the tenon 10 to 18 in. These girder caps were fastened to the tenon by four 1-in. bolts. We did not fasten the bolts through the pile at all, but clamped them to the tenon.

The bottom through which we drove the piles at Charleston consisted of marl, which is a yellow clay that is extremely hard and has, I think, about 15 per cent. of sand and is very sticky. When it comes out in the open air inside of a few hours it is so hard that you have to use a hammer to break it. It is almost stone. For the first 50 ft. of the pier the piles were driven through 38 ft. of this marl, no sand whatever, but the very hardest kind of marl. The driving was done entirely by the churning process until we got within two or three inches of the bottom, when they were driven to grade with a 4500-lb. hammer.

The work was started May 18 and was completed in three and a half months. The cost was $2.60 per sq. ft., almost double the cost of the Brunswick work, due principally to the fact that the piles were 10 ft. on centers where we had 12 ft. on centers at Brunswick, and to the heavier construction. For bracing the piers at low-water mark we put a pipe through the pile when casting it, which gave a hole 6 in. above low water through which a 1-in. bolt fastening two 6 by 12 in. low-water girders was placed. Also cross bracing was fastened to the superstructure and to these low-water girders.

The test-load required in the case of the Charleston pier was 400 lb. to the sq. ft. or 20 tons to the pile and the government had the privilege, of course, of choosing any piles they wished us to test; instead of testing the piles at 20 tons to the pile, we loaded them to 30 and kept the load on for forty-eight hours. The piles stood up so well to this test that the government engineers were able to find no settlement whatever.

DISCUSSION.

A MEMBER. — I would like to ask how much opening is made in the ground in this churning process and whether it fills in so that the pile is steady.

MR. CANNON. — We found if we shut the water jet off, in not more than a minute afterwards it was impossible to move the pile. The material filled in so rapidly that the pile could not be moved a minute after the water jet was shut off. The jet was always on while we were churning.

MR. F. L. FULLER. — What was the pressure used?

MR. CANNON. — One hundred pounds. We found that was all that was necessary. By using 100 lb. the hose lasted much longer and it did the work as quickly as 150 lb.

MR. FOX. — You didn't have any trouble in hard driving with pieces of iron filling it?

MR. CANNON. — Never in the hardest driving.

MR. G. T. SAMPSON. — You say your concrete mixture was 1: 2: 3?

MR. CANNON. — Yes, sir; 1: 2: 3. The chief reason for it was to make a concrete that was absolutely waterproof. That gave us an excess of 25 to 30 per cent. cement and, as I say, it was done to keep the water out of the concrete.

MR. SAMPSON. — I was going to ask whether there is any fear from disintegration.

MR. CANNON. — Some of those piles have been driven nearly three years. I was there three months ago and took special pains to examine them to see if there was any sign of disintegration. I knew the conditions around Boston harbor and was interested to watch the concrete work under new conditions. I have failed yet to find a single instance of disintegration in the concrete down there with salt water or anything else.

MR. SAMPSON. — The temperature there is always above freezing.

MR. CANNON. — I attributed it entirely to the temperature.

MR. SAMPSON. — Did you use fresh water?

MR. CANNON. — Yes, no salt water in the piles whatever. And we used fresh water sand. We did not make any experiments at all with salt water. The United States engineer at Key West had an article in the *Engineering News*, relative to carrying on experiments at Key West relative to the action of salt water and fresh water and air on the reinforcements inside of concrete. Two years ago he made

quite a number of samples. He put some in salt water, some in fresh water and some in the air. The samples in the salt water he examined shortly before I saw him and he told me there was absolutely no corrosion whatever, or indication of rust on the reinforcement on the inside of the concrete in salt water. With the samples in fresh water, the reinforcement showed a little corrosion and those in the air showed the most of any. We had a few piles left over, and there were a number of pieces lying around at Brunswick, and I looked at those not a great while ago and found no action whatever by the salt water on the reinforcements. The piles show no deterioration whatever on the outside. The surface is just as good as when they were put down.

Mr. J. P. Snow. — In driving sheet piling with a lighter by the churning process, did you have any means of holding the sheeting in place?

Mr. Cannon. — Of course the bottom of the pile was held in place by the beveled corner. The top was held in place by means of a clamp made to fit into the groove of the pile we were driving. It had a groove on the outside and a tongue in the groove of the pile previously driven. Held in this way the pile could move but little. It might move from a half an inch to an inch, but not enough to put the pile out of position.

Mr. Snow. — Could you govern the pile by that churning process so that it would come right as to height?

Mr. Cannon. — Absolutely. In both piers and in the work at Charleston I do not believe there was one pile an inch out of level.

Mr. Snow. — Referring to the Brunswick work and comparing the conditions there as to price of labor and hours of work per day, do you think a work similar to that in Boston would cost more or less?

Mr. Cannon. — I don't think it would cost any more. I think that while hours of labor are longer in the South, the superior character of the labor you get here in Boston would more than make up for the difference in time. The labor down there is not good.

Mr. Fuller. — What clearance did you allow between tongue and groove of pile?

Mr. Cannon. — About one-quarter of an inch. The fact is that in the churning process the piles chafe enough so as to make a nice fit and while in our case they did fit, it was customary to leave a small space where the tongue fitted into the groove.

Mr. Fuller. — I was interested in the shoulder on the pile. How is it possible to get the piles so that the shoulders will be just level? I should think that some places you would drive deeper than in others.

Mr. Cannon. — Of course, there is one thing in the southern country that is particularly favorable to this method of construction. It is a flat country. Everything is flat there. Almost all kinds of subsoil lay on a horizontal plane. For that reason it is easy to determine what the bottom is. What you find in one place you can count on finding 200 ft. away in any direction. That helped out a good deal. But I should not be afraid to undertake that almost anywhere. From the experience we had there with different characters of soil, I think we could drive piles to sustain almost any practical load you would want to put on them.

Mr. William Parker. — I would like to ask how you determined in advance the length of the piles to be used.

Mr. Cannon. — At Brunswick it was determined by means of a test pile. Then of course, as I have just said, the bottom lies so uniform that one test is almost as good as one hundred. One thing we did have trouble with at the beginning, and that was in finding out when to stop the water jet and use the hammer in order to bring the piles to a firm bottom, so they would not settle after the load was put on. We very soon found that out. The first few piles driven came underneath the railroad tracks and they settled about 2 in. for about four or five bents out. After that there was not a pile that settled. We never had any at Charleston that settled. I do not think there is any trouble whatever from that.

A Member. — Was anything specified by the parties during the work as to the character of the cement to be used? What I want to know is whether certain requirements were stipulated?

Mr. Cannon. — The specifications at Brunswick were drawn up particularly to fit salt water work, and that called for not over 8 per cent. of alumina to appear in the cement, and I think our other requirements were all the same as the standard specifications. But we had a great deal of difficulty in getting a cement that would meet the requirement of 8 per cent. of alumina. We finally did get some and found one mill able to furnish it and I believe only one. Out of quite a number of thousand carloads of cement I think only two were rejected.

A Member. — Where did the cement come from?

Mr. Cannon. — It was Old Dominion Portland cement from Fordwick, Va.

A MEMBER. — What kind of lumber did you use?

MR. CANNON. — Yellow pine. We were particularly fortunate in getting a mill so situated that there was no poor lumber on the property. It was all hill pine and about 75 per cent. of our lumber was classified as prime lumber.

A MEMBER. — Is creosote required in the pine?

MR. CANNON. — That is a question I have looked into quite a little. I made a trip from Mobile to New Orleans over the Louisville & Nashville Railroad. I presume they have more creosoted pine and timber on their road than any road in the country. They have their own creosoting plant. They mark every pile they drive and keep track of it right along. The superintendent showed me marked pine that had been in there thirty years. I do not mean that all of the piles would last any such length of time, but they would not have to be replaced inside of ten or twelve years, and the majority of them would last fifteen or sixteen years and many of them much longer. But they get in that district a class of pine the grain of which is exceedingly coarse and which contains a good deal of sap, so they are able to put a large quantity of oil into the piles. That is undoubtedly the reason why their creosoted piles do so well.

[NOTE. — Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by April 15, 1909, for publication in a subsequent number of the JOURNAL.]

CAVING BANKS.

By B. M. Harrod, Member Louisiana Engineering Society.

[Read before the Society November 9, 1908.]

The sources of rivers are generally springs, in elevated and forested regions, discharging water filtered through the soil. The rivulet thus started increases in volume by combination with others of its kind, and by the direct run-off from the surface of the drainage basin. The water is at first free from sediment, but soon loses this quality by the waste of surface soil which is constantly going on as the result of rainfall and other atmospheric influences, and also by the material eroded from bed and banks in securing a waterway adequate to the volume, as it constantly increases from tributaries and from direct run-off.

The upper reaches of rivers are generally in regions of steep slopes, where the disintegration of surface soil and its transportation and delivery into the streams is going on at its maximum rate, while the material in which the river is excavating its bed is generally an old and hard geological formation, which erodes slowly. On the other hand, along the lower reaches of rivers, the land surface flattens, the rate of disintegration by rain decreases, and the soil of the bed and banks, being generally of more recent and softer geological formation, becomes more subject to erosion by the river's action.

It is, therefore, generally true that the main contribution of sediment to the upper reaches of a stream is from soil washed from the surface of the basin by rain, while in its lower reaches the larger proportion of sediment borne by its current is derived from the erosion of its bed and banks. This last statement is particularly true of rivers which enter and flow through alluvial plains to the sea, and of this the Mississippi is an extreme illustration.

It may be said of this great sediment-bearer that its load from Cairo down to the Gulf consists almost altogether of the immense masses of alluvial bank soil undermined by floods and caving during low water, and of only such surface soil washed into the upper parts of the main stream and its tributaries as is light enough for transportation for long distances by the current.

This material may be classified as follows:

1. That carried in continuous suspension, on account of its lightness.

2. That carried in discontinuous suspension, on account of weight.

3. That rolled along the bottom, in which case the movement is also discontinuous.

Of these three classes, the second is in the Mississippi, below Cairo, by far the largest, and its principal source is the caving banks of the river. It is of this material that the bars are mainly formed, and the points on the convex sides of the bends which throw the current against the opposite and concave shore.

From every point of view, therefore, whether the improvement of navigation, the permanency of levees, the saving of thousands of acres of the most valuable farming lands, or of the highly improved towns and cities on its banks, the prevention of caving is the most important factor in the improvement of the river. It is also the most difficult, not because the principle of construction of bank protection work is not well understood, but on account of the vast scale its practical application requires on the Mississippi.

Permanence in the location of the river's bed and banks can only be attained when an equilibrium is established between the eroding power of the current and the resistance of the material of the banks. To reach this is the constant struggle of nature. If the stream prevails against the shore, the consequent caving lengthens the bends in the part of the river concerned in the struggle, until the slope, velocity and erosive power are so reduced that caving ceases. When a cut-off occurs, the river's length is reduced and its slope and velocity increased until its erosive power regains its activity. This effort towards adjustment is evidenced by its history. Within the eight hundred miles from Cairo to Pointe Coupée there have been twenty-four or more cut-offs, shortening the distance about three hundred miles, yet the length has not been permanently reduced. What length was lost by cut-offs has been regained by the intensified erosive action of the current.

The physical conditions of the river are so constantly changing that a stable equilibrium between attack and resistance is never attained. As " unstable as water " is a proverb, yet water is not much more unstable than is an alluvial river bank. With every change of stage there is a change in the direction and

velocity with which the current attacks the bank. As the river rises, its attack drops lower down the bend and moves up again with the falling water. Any change in the bank by caving directs the current against points above and below, before unattacked. Again, the material of which the bank is composed changes greatly within short distances. It may be nearly pure sand, or largely of clay, or of any proportion of these ingredients. The more sandy, the more friable it is. A substratum of sand, capped with clay, makes a dangerous bank, for having a flatter angle of repose it is easily scoured out, and then the clay, unsupported, falls of its own weight. Ponds near the river bank leak through the intervening material into the river, lubricate the sand and clay and often thus cause serious caving. The difference in the stability of banks of different composition is well exemplified within the limits of this city. None steeper than that at Carrollton is known on the river. Part of it stands at a greater slope than one on two, too steep for the laying of mats with security, yet for the entire recorded period of observation the average annual recession of the shore line has not exceeded six feet. Along the third district front the slope is quite flat, about one on four, yet hardly a year passes without the extensive sinking of the bank and levee in one or more places.

The process of bank building is the same as is now going on in the dry bars and high battures with which we are all familiar. The coarser or more sandy the material, the more rapid the current by which it was deposited, while the clay or muddy strata were dropped by gentler currents. Thus, at the head of a dry bar, where the first shock of the current is received, is often found scattered gravel. Lower down is found sand ranging from the coarser to the finer, as the velocity is diminished, while at the tail of the bar, in the stiller water, under the shelter of the crest, is found a deposit of very fine silt or mud. Under these various conditions presented by the river and its banks, the prediction or location of a probable cave is difficult and doubtful. I know of no guide for the engineer but experience through many years of observations. It takes time to get "river sense." I don't think theories involving quicksand are entitled to much consideration. My experience is that this is a very scarce material, and its assumed presence is often claimed to cover the want of exact information.

When the erosive power of the flood has deepened the thalweg in a concave bend, and shoved it so near the shore that the slope of the bank is steeper than the angle of repose of the

material or any part of the material of which it is composed, caving ensues. So, what the engineer really requires is a knowledge of the angle of repose of the several kinds of material entering into bank building, and "there's the rub."

Of course caving is most active when the banks have been long saturated by high water and its support then withdrawn by the ensuing fall. The extreme of conditions favorable to caving has been presented this year, when a flood of great height and unexampled duration has been followed by a rapid fall to an excessively low stage.

The effect of the system of wharf construction used on our city front on caving is doubtful. The first result is the slackening of the current as it flows through the forest of piles, thus preventing erosion of the upper bank. But this protection extends not more than one third of the way from the top of the bank to the bed of the thalweg, and the lower part is left not only unprotected, but probably is subjected to a slope-steepening scour, since the arrest of flow in one part of a river section intensifies it in others, particularly in those nearest the obstruction. Thus a marked scour is observed along and under the free edge of mats for bank protection, and they have to be built flexible so as to drop into the grooves thus formed. Of course the reduction of current among the piles causes a deposit along the top of the bank, and this, unless removed as the river falls, may become a source of danger from added weight. It is difficult, however, to see that, under the conditions, any other method of construction is practicable.

A bank of fair stability would not be affected by the weight of ordinary structures or by the vibration of railroad trains, while, in other cases, its equilibrium may approach instability so closely that this additional load would be all that may be needed to start a cave. As the condition of a bank in this respect is difficult to ascertain, it is certainly a wise precaution to move such burdens as far back as possible.

No method of bank protection, reasonable in either principle or practice, has been devised other than a flexible brush mat, thick and dense enough to relieve the bed from erosive currents, extending from the low-water line to a little beyond the thalweg, sunk and held in place with sufficient stone; then grading the bank from the low-water line to its top on a slope, preferably as flat as one on four, and covering this with stone, riprap, preferably not less than 10 in. thick, with the interstices filled with spalls. Unfortunately, this costs about $150 000 a mile.

The lion and the lamb are not more different in disposition and appetite than is the Mississippi River in high flood and at low stages — the one a boisterous and impetuous torrent; the other gentle, feeble and of little depth. If it were possible to abate the annual range of stage of forty or fifty feet, and to reduce the flood discharge of 2 000 000 sec.-ft. and correspondingly increase the low-water discharge to 100 000 sec.-ft., so that a uniform condition of stage and discharge prevailed throughout the year, the cause of caving would be removed. If the stage and discharge were thus made uniform throughout the year, stable equilibrium between the erosive power of the current and the resistance o the banks would soon be established, the location of the river channel and its banks would soon become permanent, the great differences of width and slope would disappear, and the improvement of navigation and the permanence of levees would be established. But this is no more possible than a uniform rate of rainfall throughout the year over the 1 250 000 square miles of the river's drainage basin.

In the meantime, taking the physical condition of the river as we find it, it is. I think, a conservative statement that for its improvement there is needed between four and five hundred miles of revetment in the eight hundred miles from Cairo to the mouth of Red River Below Red River the rate of caving is so much less that the application of the system may be limited to the front of towns and cities and other important points.

When the erosive force of the current is thrown against a concave bend in the right bank, it causes caving for two or three miles. It then crosses to the opposite shore, and through the length of reach required for the crossing, neither bank caves; but when the crossing is completed the caving is transferred to the left bank. Thus we have a length of river where the right bank caves, another where neither bank caves, and then one where the left bank caves. I, therefore, have estimated the aggregate length of caving bank at about one half the length of the river, divided equally between the two banks.

The actual length of bank subject to erosion to a greater or less extent exceeds that here given, but in many places it is too slight for such heroic and costly treatment. Besides, it is believed from experience that the conservative effect of the fixation of a bank, by revetment, extends beyond the length of bank to which it is actually applied. The deflection of a current from a bank naturally permanent, or artificially made so, is towards a certain point lower down on the opposite side. But if the

point of deflection is constantly changing, the point of attack lower down is also movable. Therefore, fixing one part of the bank tends to preserve another.

Taking the cost per mile and the number of miles as given above, gives the cost of revetment from Cairo to Red River at about *seventy-five million dollars*. To this must be added the sum required for special works below Red River, of which those in the harbor of New Orleans are, in every respect, the most important.

[NOTE. — Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by April 15, 1909, for publication in a subsequent number of the JOURNAL.]

THE WATER HYACINTH PROBLEM.

By John Klorer, Member of the Louisiana Engineering Society.

[Read before the Society, December 14, 1908.]

To those of you who are interested in the drainage of the low areas in our neighboring parishes, or to those of you who are interested in water transportation in most of our Louisiana streams, the water hyacinth needs no introduction. It made its appearance here at the time of the Cotton Centennial Exposition in 1884, being shown then as an exotic plant which readily made friends on account of its beautiful bloom and the little difficulty experienced in growing it. From New Orleans some of the plants were taken to the surrounding parishes and cultivated in ponds and in gardens as admirable aquatic specimens. It is supposed that they rapidly outgrew the limited water surface given to them and that they were cast out or probably dumped into some nearby stream and thus found conditions favorable to growing undisturbed.

The plant is propagated by seed, but more vigorous and rapid growth of new plants is attained by the parent plant sending out root-stems, or rather, stolons, eight or ten inches long. At the end of each stolon (which is the botanical term for the trailing basal branch of the plant) there is formed a small cluster of leaves which develops into an independent plant with roots of its own but remains connected with the older plant. The parent plant may send out as many as five or six of these stolons, and the resulting plants, in turn, put forth secondary stolons, so that it is not unusual to find a colony of 25 or 30 plants attached to each other. As will be readily seen, the result is the formation of a thickly-matted and connected subaqueous mass that practically stops navigation by small boats and greatly interferes with the movement of larger boats. So rapid is the growth that a bayou of 150 feet width and having only a narrow fringe of hyacinths along the shore in March will be completely covered with plants in June.

I have been told that the first operations toward the removal of the hyacinth were carried on in the early nineties by the saw-mill interests along Bayou Plaquemine, the method of riddance being to throw the plants on the bank with pitchforks. Along in 1896 or 1897 it became realized that that which had

been innocently introduced into the state as a thing of beauty had become a nuisance and was destined to become a problem. At about the same time it became known that the water hyacinth was giving considerable trouble also in Florida, especially in the St. John's River. An appeal for assistance was made to the federal government in 1897, and under the provisions of the Sundry Civil Act of that year a board of engineer officers was appointed to investigate the extent of obstruction to navigation in the streams of Florida and Louisiana and to determine a method of checking the growth of, or removing, the water hyacinth.

This board recommended the construction of boats fitted with crushing machinery and the use of booms as adjuncts to the boats to prevent the entrance of hyacinths into navigable streams. It was not until 1899 that the first appropriation, $25 000, was made. With this, a stern-wheel boat, the steamer *Ramos*, was purchased and equipped for the work and commenced operations in Bayou Plaquemine in June, 1900. Briefly described, the machinery and method of operation were as follows: At the forward end of the boat was a conveyor four feet wide which dipped into the water and carried the hyacinths up to a set of rollers where they were crushed into a pulp and then discharged on the bank by means of another conveyor, the whole scheme being an adaptation of the manner of crushing cane as practiced in Louisiana sugar houses. This method was found to be very slow, unsatisfactory and expensive, costing about 6 cents a square yard.

Experiments were then made to attempt destruction of the plant by spraying it with various commerical acids, such as nitric acid, sulphuric acid, hydrochloric acid. These were used in diluted forms of varying strengths, but it was found that in order to get effective results the solutions had to be so strong and, therefore, so expensive as to make this method of extermination prohibitive in cost. An experiment was also made with Beaumont fuel oil, it being very cheap at that time, with the expectation that if spread on the water surface in a thin film and set afire it would speedily destroy the plant. It was found to be very difficult to fire, except when used plentifully, and in that case it burned the tops of the plants only, and a renewed growth appeared soon thereafter.

In 1902, there was tried a patented chemical solution sold by the Harvesta Chemical Company of this city, which proved very effective. The selling price was 3 cents per gallon, and one gallon, if properly applied, was guaranteed to kill 12 square yards of

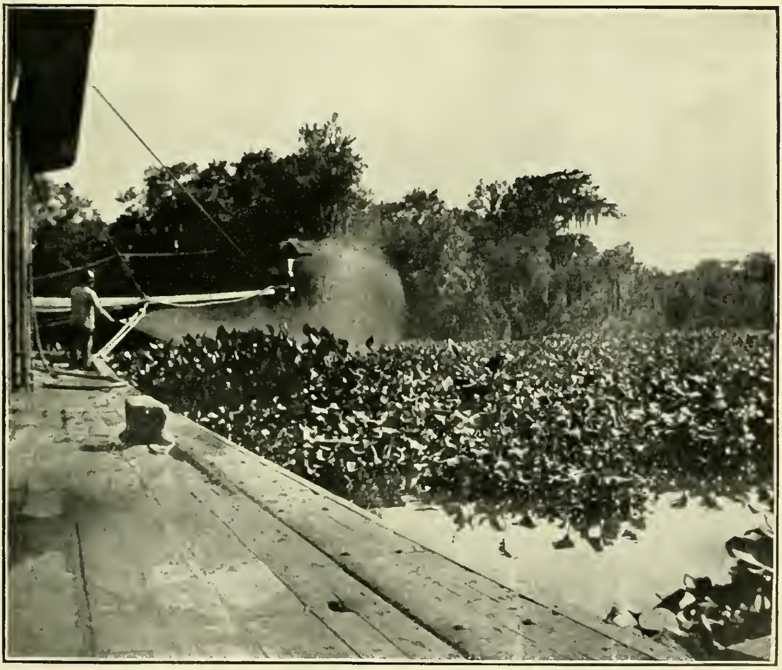
healthy plants. As this was much cheaper than any method used previously to that time, the crushing mill on the *Ramos* was removed and the boat equipped with tanks and pumps for spraying operations. The results accomplished the first year of spraying were very encouraging. The Harvesta compound continued to be used until 1905, when a solution recommended by the Department of Agriculture as being very effective in destroying the Canadian thistle was tried and proved highly satisfactory. It consisted of a mixture of arsenious oxide, commercially known as white arsenic, and carbonate of soda, or sal soda, still better known as washing soda.

It is the solution at present used by the government on the two boats engaged in the work, and is prepared as follows: Each boat is equipped with two tanks that are placed one above the other for convenience. Into the upper one, or boiling tank, are placed 400 pounds of white arsenic, 400 pounds of sal soda and about 400 gallons of water. Steam is introduced into the tank by means of a perforated steam pipe near the bottom, and the mixture is boiled about one hour, or until all the arsenic is taken up in solution. It should perhaps be stated that white arsenic is insoluble in water but is soluble in an alkali solution, which explains the use of the sal soda. Any other alkali would answer as well, but sal soda is used on account of its small cost. This mixture, prepared as above, is called the concentrated solution, and is eighteen times stronger than is necessary to have a killing effect on the plants. In practice we divide the concentrated solution into two batches and let down one of them into the spraying tank, to which water is added until there are 3 600 gallons of mixture. In other words, for each pound of arsenic used we have 18 gallons of spraying solution. This proportion was determined experimentally after localizing several areas of hyacinths with rope booms and spraying them with solutions of varying strengths. The conclusion reached was that solutions weaker than the one mentioned did not prove effective, while those stronger were unnecessarily so.

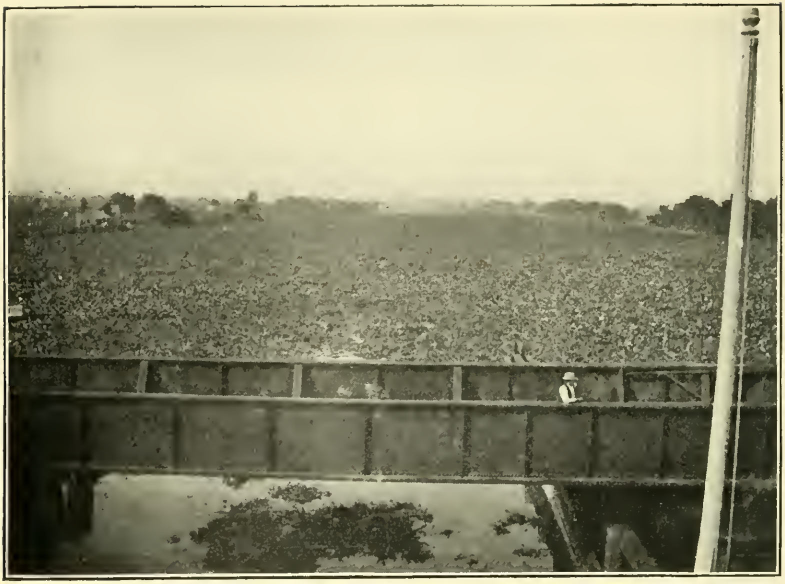
As to cost, the prices of the ingredients entering into the solution vary with the supply of the local market. Arsenic in large quantities can usually be bought for about 6 cents a pound, and sal soda for 1 cent a pound, which makes the spraying solution cost about $\frac{1}{10}$ of a cent per gallon.

In spraying, we use three lines of one-inch hose located at the forward end of the boat. The hose lines are directed by hand and are tipped with Fuller nozzles, these being preferred on

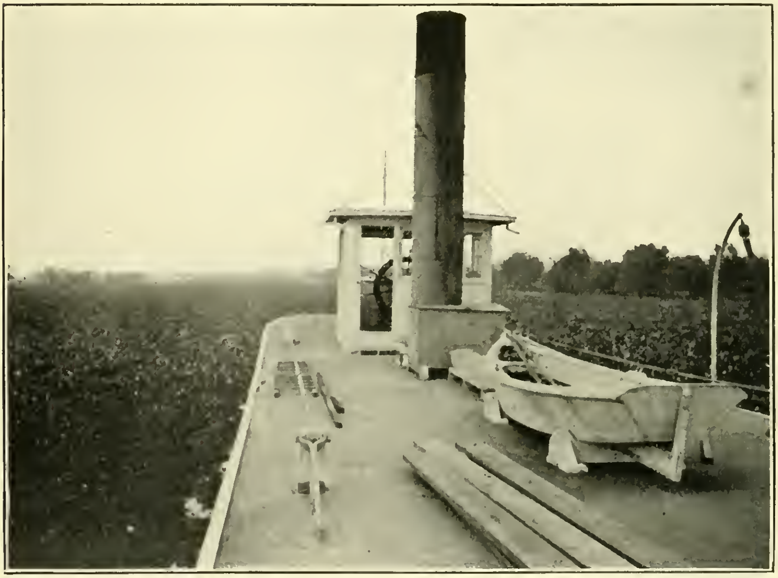
One of the Spray Boats used by the United States.



Spraying from End of a 50-ft. Boom on U. S. Steamer "Ramos."



Bayou Bœuf, La., from Southern Pacific Railroad Bridge.



Stuck in a Hyacinth Jam.

account of the better results they give in distributing the solution as a fine spray or mist. The cost of applying the solution involves the working expenses of the boat and generally averages about $1\frac{1}{4}$ cents per gallon sprayed. This added to the cost of the solution makes the cost per gallon sprayed about $1\frac{3}{4}$ cents, and one gallon of solution will kill about 10 square yards of hyacinths.

The effect of the solution on the hyacinths is not noticeable until the next day, when it is observed that the tip ends of the leaves are beginning to wilt and the plants emit a peculiar odor somewhat like that of new mown hay. One or two days of hot sunshine thereafter will quicken the action of the solution and the plants then become brown and shrivelled in appearance. Ten days after spraying there is no green color in evidence; the hyacinths float about in small bunches, but no longer erect, and rapidly disintegrate. As the plant is about 98 per cent. water there is very little residue, and two weeks after spraying, what was a dense mass of vegetation has dwindled to a few floating wisps, the remnants of roots, stalks and leaves.

The question is often asked: What is the effect of this poisonous solution upon fish life? As far as has been observed, there is no indication that it is injurious — there are no dead fish in evidence. As a matter of fact, it is the usual pastime of the crew when off duty to fish at the locality where spraying operations are in progress, and they do not hesitate to eat the fish they catch.

That the solution used kills the plants absolutely has been proven in every instance where conditions were such as to permit close observation of the effect of spraying and such as to prevent the introduction of new plants within the area sprayed. It sometimes happens that where the hyacinths are heavily leafed, or of unusually thick growth, some of the smaller plants are sheltered by the larger and are not reached in spraying. The presence of these protected plants in the midst of dying plants gives the erroneous impression that they are a renewed growth from the roots of sprayed hyacinths, but closer observation will prove that this is not so.

In conducting spraying operations it has been found unprofitable to spray while dew is on the leaves or immediately after a rain. To get best results hot sunshine is necessary; consequently the progress of the work depends in a measure upon good weather. The working season is from April until the middle of October. After October the plants grow very slowly and during the winter months not at all. The first frost kills the tops.

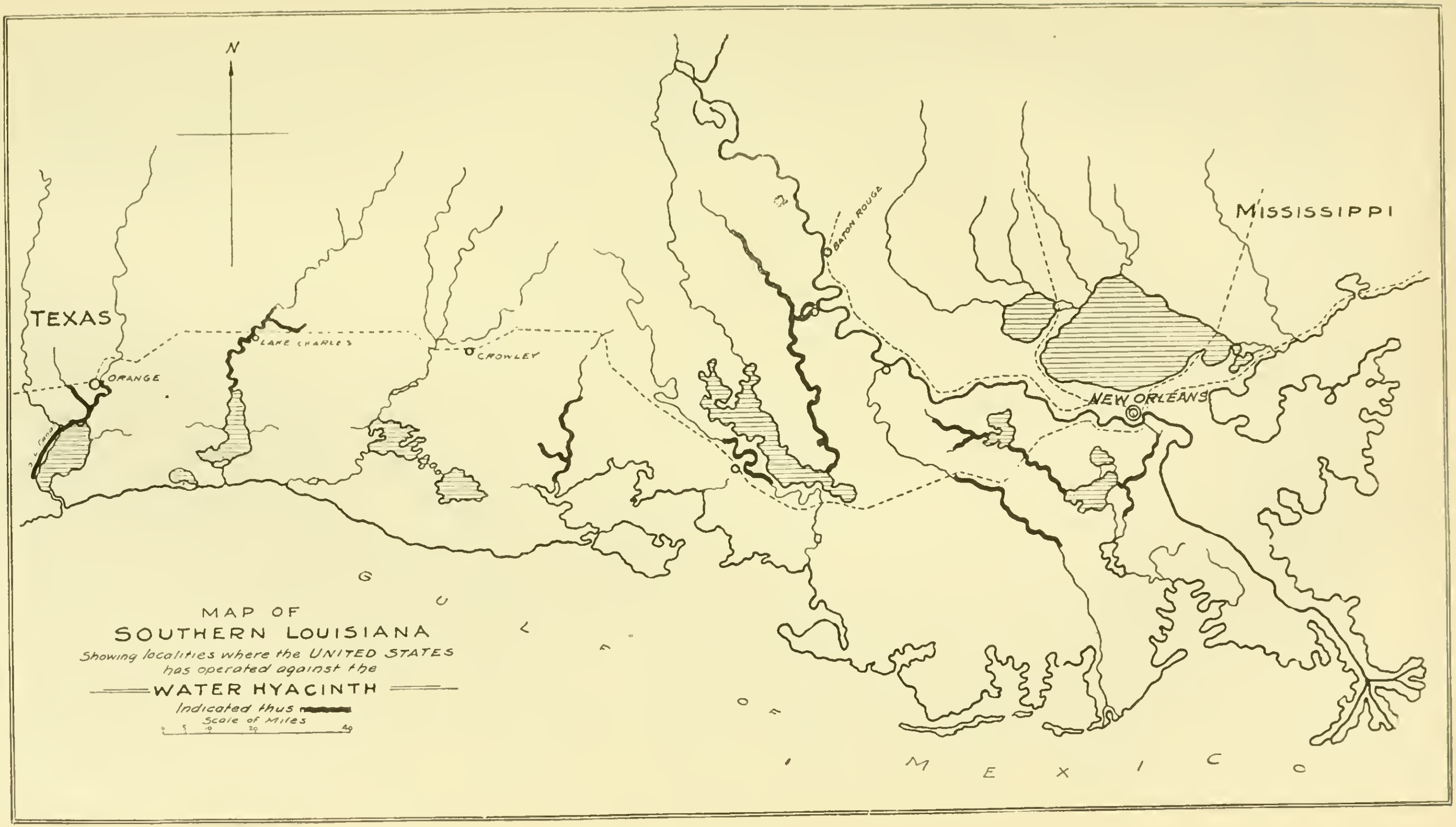
Work is suspended accordingly a few weeks before, and in anticipation of this occurrence.

Such is the method of removal by spraying. While satisfactory in some respects, it has its limitations. As long as the hyacinth-infected stream is a navigable one, it is possible to kill every hyacinth in it by spraying. But the usual Louisiana bayou or river has many tributaries which are non-navigable, and, therefore, inaccessible to the spraying boats. These serve as excellent breeding places for the pest. It is the practice to boom these feeders in order to prevent an influx of plants into the navigable stream below, but it is a difficult matter to keep them boomed for any length of time on account of the acts of trappers, hunters and swampers, who open the booms and neglect to close them. The result is that a subsequent heavy rain and its consequent freshet will move large quantities of hyacinths out of these feeders and cause jams at the lower end of the stream where the current is too slack to carry them off.

Many bayous in this state empty into the Gulf and for a distance of forty or fifty miles from their mouth there is a daily tide effect. When hyacinths are present they move backward and forward, respectively, with the incoming and outgoing tide, and generally in great masses. Where these conditions exist, the most effective as well as economical way to remove the plants is by the operation of automatic booms placed at intervals of about 5 or 6 miles. The automatic boom is rigid and is built of coal-boat gunwales or other long pieces of timber bolted together to form a floating gate about 80 or 100 feet long and 4 feet wide. One end of this gate is attached to a cluster of piles by a circular iron strap in such manner as to permit the gate to swing open when the current is downstream and to close with the incoming tide. With a series of these booms in operation, a system of "locking" the hyacinths is established and each outgoing tide moves them 5 miles nearer the Gulf. After reaching salt water the hyacinth soon dies, due to the fact that the organic matter or plant food upon which it thrives is absent in salt water.

From the writer's observation, covering a period of five years, during which he had local charge of the work conducted by the government in "removing the hyacinth," it is his opinion that the hyacinths are fast taking possession of "Louisiana's matchless waterways" and that within a few years navigation will be impeded in all save the largest streams of this state.

We hear much in these days about improving our inland waterways; deepening this bayou; widening that; connecting


MAP OF
SOUTHERN LOUISIANA
Showing localities where the UNITED STATES
has operated against the
WATER HYACINTH
Indicated thus
Scale of Miles
0 5 10 20 40
N
TEXAS
MISSISSIPPI
ORANGE
LAKE CHARLES
CROWLEY
BATON ROUGE
NEW ORLEANS
G U L F
O F
M E X I C O

some other bayou with some canal; digging an intercoastal canal. Throughout the state interest in water transportation has received a fresh impetus the last year or so, and many projects are under way. To my mind the one factor which will interfere most with the realization of the anticipated results of these different projects will be the water hyacinth. It matters not how wide your stream is, or how deep, it will not be navigable throughout the year if the hyacinths are allowed to take possession of it. Incredible as it may seem, I have seen boats drawing three or four feet "hard a ground" on a mass of hyacinths in a bayou 25 feet deep.

The work done by the government heretofore has been under the provisions of Rivers and Harbors Acts, in which it was specifically stated that the removal of the water hyacinth was to be confined to those streams only where navigation was obstructed, or likely to become obstructed. Accordingly, the work done has been only towards alleviating conditions where navigation has already become blocked or nearly so. What is needed is to have an appropriation that will permit a campaign of extermination to be undertaken. And unless the work is prosecuted with this object in view the benefits obtained are only temporary. A water hyacinth should be considered by navigation interests in the same light as a stegomyia mosquito is considered by the health authorities. Every boat plying on streams infested with the water hyacinth should be equipped with a tank of spraying solution and a spraying outfit and not wait for the government to do it all. By intelligent coöperation on the part of steamboat men and the development of a sympathetic public interest to stop the tampering with booms, much good can be accomplished in controlling the spread of the growth.

The complete and absolute riddance of the water hyacinth, however, is a much larger problem and one which deserves the earnest thought and study of scientific men. On account of the immense area infested, and the inaccessibility of the larger part of this area, it is almost impossible to extirpate each and every plant by mechanical means, or by present methods. The most inviting field for experiment, and the only one to which we may look for the complete riddance of the pest, is plant pathology. The investigating botanist may probably find some natural enemy to the plant, some malady, some parasitic fungus, that could be cultivated and spread among the hyacinths and which at the same time would not be a menace to the agricultural interests.

[NOTE. — Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by April 15, 1909, for publication in a subsequent number of the JOURNAL.]

DISCUSSION OF PAPER BY H. W. CLARK, "SOME OBSERVATIONS OF METHODS, COST AND RESULTS OF SEWAGE PURIFICATION ABROAD."

(Vol. XLI, Page 231, November, 1908.)

Mr. Langdon Pearse (*by letter*). — The writer has been very much interested in Mr. Clark's paper and the ensuing discussion, particularly the part pertaining to the sprinkler problem. He regrets that the discussion did not bring out more definitely the comparative costs per acre of the various methods of sprinkling proposed, as well as their relative efficiencies. In the working of a sprinkling filter, the distribution of the sewage is a very important matter, but the theoretical distribution obtained from experiments made in a laboratory or inside a shelter will undoubtedly be quite different from that in the open on a large filter. At Columbus, Ohio, the writer conducted a long series of experiments on different cones and nozzles, as well as sprinklers, under the direction of Mr. John H. Gregory, engineer in charge, Improved Water and Sewage Works. At the outset a screen was built to shield the experimental area, because moderate winds and gusts blew the spray of a standard Columbus sprinkler completely off one half of the circle of distribution.

The tests of a good sprinkler system should be:

1. Freedom from clogging.

2. Even or uniform distribution over a large area, with minimum waste area not sprinkled.

3. Operation at a low head, because as a rule the head available must be conserved to save pumping.

4. A minimum cost of installation.

Theoretically, a sprinkler to throw a square sheet would give the best distribution over the bed. In practice it is difficult to attain a square sheet, though the design, similar to that proposed by Mr. E. B. Whitman, will probably come as near as any. The question of a nozzle and cone to throw a square sheet was thoroughly discussed at Columbus, and was tried experimentally. Early in 1905 the writer drew up a series of cones, one of which was designed to throw a square sheet, the angles of the various elements of the cone being calculated to throw the sheet of the elements on to a peripheral square, just as though a projectile were being shot out. All the elements are straight lines of the

same length, to make equal skin friction. This cone is reproduced on the accompanying sketch (Fig. 1), and differs from Mr.

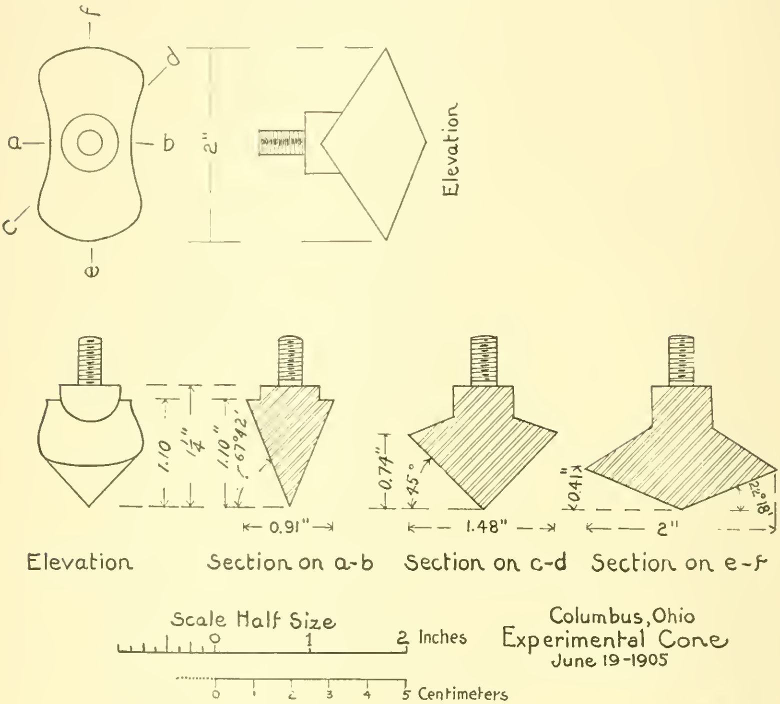


Fig. 1.

Whitman's design in being smaller and of smooth form without a sharp reëntrant feature. The four diagonal points, where the elevation is 45 degrees, were figured to shoot on the diagonals of the square. But this design was not satisfactory, as the water tended to concentrate in the two reëntrant hollows, with consequent unequal distribution. The writer had thought of trying a scheme, similar to Mr. Whitman's, of a cone with four reëntrant positions for the 45 degree elements and the flatter elements between, but time did not permit. It is possible that a satisfactory cone and nozzle can be devised on either the Columbus or the Waterbury pattern to throw an approximately square sheet on this principle, but the cost will undoubtedly be higher than for the simple cone on account of the necessarily irregular shape of the cone and possibly of the nozzle too. The improvement in distribution is a matter to be studied very carefully by actual test. A slotted form of sprinkler orifice or ring nozzle was also

proposed at Columbus, which really consisted of a cone inserted in a nozzle, with parallel faces, the angles of each varying together according to the theoretical calculation for the range. The opening in the slot or ring was narrow, so the scheme was discarded on account of the liability to clog.

For uniform distribution within circular limits under constant heads, the writer believes the best results can be had from a double cone as shown in the sketch (Fig. 2), or possibly by a

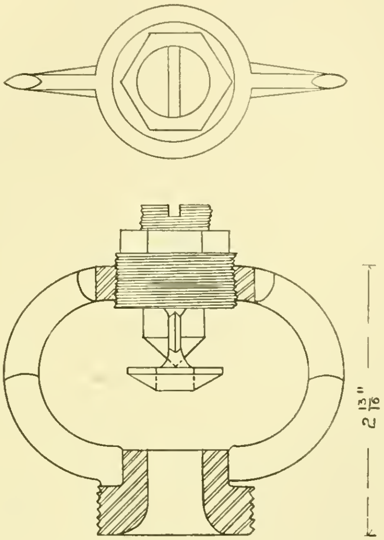


FIG. 2.

triple cone. The double cone was devised at Columbus by Mr. W. W. Jackson under the direction of Mr. John H. Gregory, and worked satisfactorily, the lower cone having a flatter angle than the upper. The reverse arrangement was found unsatisfactory. Part of the stream from the nozzle is peeled off by the lower cone, the rest passing through it to strike the upper cone. The rig shown in Fig. 2 was built for experimental purposes only, and can be materially simplified in a working nozzle.

For uniform distribution within circular limits under varying heads it is probable that good results can be obtained by a nozzle which concentrates its throw in a comparatively narrow belt, so that this belt can be moved in and out to cover the entire area. A broad belt of distribution would mean that certain portions of the sectors would receive more than their average share. Finally, if the fringes of the belt are allowed to overlap

slightly with other belts at the highest head, practically the whole area will have been covered.

The size of the cone in the Columbus experiments seemed to have little influence, as cones from ½ in. to 4 in. diameter were tried. The only effect of the larger cone was to guide the elements of throw a little longer, and slightly reduce the range.

The writer believes that a nozzle with cone is the simplest form of distribution, and he thinks it can be made the most economical, and as efficient as any other, by a thorough study of the elements of the design as a hydraulic problem, it being borne in mind that low heads and large openings are desirable.

Dr. George A. Soper. — The writer is pleased to have this opportunity to join with the other members of this society in thanking Mr. Clark for his admirable paper giving the results of his visit to European disposal works. The paper will everywhere be recognized as valuable. It gives the impressions of an expert who has long had the responsible direction of the most important sewage experiment station in the world. The paper is the more interesting to the writer since he made a visit to Europe in 1907 and traveled over much of the same ground as that covered by Mr. Clark.

The permanency of construction of British sewage works must impress all visitors who are familiar with the unsettled state of our knowledge of the principles of sewage disposal. The variety of design and the evidently great cost of those English works which have been failures are both remarkable and characteristic. Many of the works are the result of attempting to do something before it was known just what it was best to undertake — a state of affairs which has tempted Dr. Fowler to remark that it seemed necessary for the British people to proceed by the method of trial and error instead of by first principles, as is customary with our slow-going German cousins.

Every one must admit that the English people are showing admirable persistence in following up the question of the sanitary disposal of sewage and trade wastes. Not only were they very early in the field, but they have been, as a people, prominent leaders from the beginning.

Obviously there is no finality to the study of this question. The Royal Commission on Sewage Disposal, after giving ten years of study to this subject, now recommends that a permanent central sewage disposal commission be appointed which can carry on researches and supply local authorities with expert information and advice. This is somewhat after the pattern of the

board of health work of Massachusetts. More states should have competent central bodies to give advice on sewage disposal, water purification and other sanitary matters. Perhaps in the course of time we shall have a central sanitary commission for the whole United States, but aside from the movement for a national board of health, there seems to be no sign of it at the present time.

It is remarkable how many sewage disposal plants are now in existence. It is impossible to count all the large and little ones. The number of industrial plants which in England alone have been compelled to purify their wastes amounts to thousands. In the West Riding of Yorkshire there are 2 100 manufacturing establishments which treat their liquid wastes before discharging them into the stream, and there are over 1 000 other factories which drain into public sewers so that their wastes may be purified instead of discharging this refuse into the streams.

Referring to the disposal of domestic sewage, it would not be remarkable if, as Mr. Clark says, English and American sewage are about the same in composition. Baumeister told us many years ago that human excrement has very little to do in increasing the organic matter in sewage, and a little consideration shows that this is probably true. Sewage which represents a consumption of water of about 100 gal. per head is not necessarily more concentrated or otherwise more difficult to purify than sewage which represents a consumption of 35 gal. per capita. This is due, apparently, to the fact that a great deal of water is used for cleaning purposes. The larger consumption of water in America, as compared with the per capita in European cities, seems largely to be employed for the purposes of cleaning.

It is remarkable to observe how commonly human excreta are disposed of in Europe by other means than by water carriage. When it is said that a European city is sewered, we should not take it for granted that the excrement of all the inhabitants of that place is carried off by the sewers. For example, the city of Manchester, which has one of the largest sewage disposal plants in the world, has also one of the most extensive systems for the collection and disposition of night soil which does not find its way into the sewers. Cesspools, dry closets and other methods of dealing with human excrement are exceedingly common in European cities.

It may be gathered from Mr. Clark's paper, and other facts confirm it, that the use of septic tanks and of contact beds are not likely to remain standard procedures and that we are likely

to see them given up except under unusual circumstances. This is because of their relative inefficiency and cost. The signs indicate that sedimentation basins and percolating filters are more reliable in practice, and more simple, as well as equally scientific in principle.

The writer is strongly convinced of the force of the objections which can be raised against the odors of septic sewage. On the day that he visited the new plant at Wilmersdorf, near Berlin, the sewage, as it came to the plant, was decidedly septic, and the odor could be detected as far as the beer garden mentioned by Mr. Clark. On the other hand, the removal of the coarser and heavier solids from this sewage while it was still fresh caused little unpleasant odor in the thickly built-up section of Wilmersdorf when this operation was performed. To attempt to reduce the finer solids by septic action does not seem to be worth while, in the average case.

All are agreed that the removal and handling of the finely divided solids constitute the most serious problem in sewage disposal. At Belfast, Professor Letts expects by his process of purification to drive the mineralized nitrogen from the sewage into the air in the form of gas, and at Berlin fishes are fattened at a rapid rate in the effluents of the sewage farms. But the management of the solids is everywhere an expensive and unsatisfactory undertaking. The visitor who makes a round of European sewage disposal works and observes the amount of manual labor spent in handling sludge, and the unsatisfactory disposition which is finally made of this material, gets a very unfavorable idea of the progress made in purifying sewage.

To deal with the solids the Germans have done much to perfect screens and settling basins and have produced a good piece of apparatus in the Dortmund tank, while Dr. Travis in England has had good success with his hydrolytic tanks. But excellent though a few of these new procedures are, they seem to be inapplicable to the average large works. It cannot be guessed to-day in what way the sludge problem will eventually be solved.

Mr. A. Elliott Kimberly. — In discussing Mr. Clark's instructive and valuable paper on foreign practice in sewage purification, the writer desires to mention a few points relative to the practical aspects of contact filters now in operation in Ohio.

In the middle West, except for small cities and institutions, natural conditions prevent the use of fine grain filters, and on this account most of the larger Ohio plants make use of coarse grain

filters operated either as sprinkling filters or as contact filters. While the writer is fully in accord with Mr. Clark's views as to the superiority of sprinkling filters over contact filters, he feels that there are cases where contact filters can be adopted with satisfactory results.

While it is true that sprinkling filters generally afford satisfactory effluents, it is also recognized that their operation requires higher intelligence and greater supervision than is necessary for contact filters. With a view to eliminating pumping, and because of a probable lack of continuous and intelligent supervision after the plant is built, some recent Ohio designs for sewage purification plants comprise contact filters, generally followed by high-rate intermittent sand filters which contain sand artificially placed. The necessity for more than one treatment is based perhaps upon the variable efficiency of single contact filters, as illustrated by the practical performance of the three largest contact filter plants in Ohio. The three typical contact filter plants in Ohio in point of size, age and efficiency are at Mansfield, Lakewood and Marion, respectively.*

The Mansfield plant is widely known as one of the first so-called bacterial sewage purification plants in the Middle West. The plant consists of a pumping station, septic tanks holding about twenty-four hours' flow, aërating devices and contact filters. The average dry weather sewage flow is about 1 000 000 gal. in twenty-four hours. The contact filters contain 4 ft. 9 in. of crushed cinders from $\frac{1}{4}$ to $\frac{3}{4}$ in. in size and comprise five units with a total area of 1.25 acres. They are operated automatically on the fill-and-draw plan at a rate of about 800 000 gal. per acre in twenty-four hours, or about 9 600 persons per acre, or 2 000 persons per acre-foot.

From the standpoint of efficiency the Mansfield contact filters have normally produced a well-purified stable effluent. The filters have, however, sludged materially and some of the filtering material has been renewed. The filters have been in service seven years.

The Lakewood sewage purification plant consists of septic tanks holding about twenty-four hours' flow and single contact filters. The average dry weather sewage flow is approximately 500 000 gal. in twenty-four hours. The contact filters contain 5 ft. of crushed cinders, which range in size from $\frac{1}{8}$ to $1\frac{1}{2}$ in. and consist of five units with a total area of 0.625 acre. They are

* For full description and discussion, see forthcoming report of Ohio State Board Health on Water and Sewage Purification.

operated on the fill-and-draw plan by an automatic apparatus. These filters have very successfully handled the weak Lakewood sewage and have normally produced a non-putrescible effluent. The rate of operation averages about 800 000 gal. per acre in twenty-four hours, and the population load is 11 200 persons per acre, or 2 240 persons per acre-foot. These filters have been in service seven years.

The Marion sewage purification plant consists of septic tanks holding about fifteen hours' flow, contact filters and subsidiary sand filters. The contact filters comprise six units with a total area of 0.55 acre. They contain 2 ft. 9 in. of crushed limestone, which for the upper layers ranges in size from ½ to 1½ in.; the lower foot is of 2-in. size. These filters are hand operated in the day time on the fill-and-draw plan, but at night are operated as strainers with open outlets. These stone contact filters have never produced a stable effluent, and unless the contact effluent be treated on the sand filters the Marion sewage is not purified to a non-putrescible state. The strong Marion sewage after sedimentation in the septic tanks is applied to the contact filters at a rate of about 590 000 gal. per acre in twenty-four hours. The approximate population load is 14 500 persons per acre, or 5 250 persons per acre-foot. This plant has been in service three years.

At Mansfield and Lakewood one contact treatment with cinder filters produces a very satisfactory effluent. At Marion, single contact in limestone filters does not afford sufficient purification. The Mansfield and the Lakewood sewages are weak; the Marion sewage is strong. The former filters contain cinders, the latter limestone, and are, moreover, receiving the sewage of a greater population per acre. Whatever may be the explanation of the different efficiency of these plants, the fact that contact filters on a single basis are not reliable causes engineers, if possible, to plan for sprinkling filters, or else to provide finishing filters of fine grain material operated on an intermittent sand filter basis, following single contact treatment.

Notwithstanding the marked advance in favor of sprinkling filters, the writer believes there is a field for contact filters either alone or in combination with finishing filters in cases where sprinkling filters are inadmissible because of obligatory pumping plants or because local conditions indicate that sprinkling filters, if constructed, would not receive the required supervision.

OBITUARIES.

Ai A. Abbott.

Member Montana Society of Engineers.

Ai A. Abbott was born on the first day of December, 1866, at Fairfield, Lenawee County, Mich. When he was twelve years of age his parents moved to Lansing, Mich., where, in the public schools, he received his early education. In due time he became a student at the Michigan College of Agriculture, graduating from the same in 1887 with the degree of B.S. Some two years after, he attended the Michigan School of Mines at Houghton and received the degree of "E.M." as a member of the class of 1893. After his graduation for several years he occupied the following positions: Instructor in drawing, surveying and mechanical engineering, Michigan School of Mines; draughtsman, S. E. Cleaves & Son, Hancock, Mich.; civil and mining engineer, Coulterville, Cal. Soon after his marriage to Miss Annette Snyder, of Salem, Ohio, in 1897, he went to Butte, Mont., and secured employment in the engineer's office of the Boston and Montana C. C. and S. M. Company. After working in said office for about two years he was chosen foreman of the West Colusa Mine, one of the large properties of the Boston and Montana Company, serving in this capacity for about two years. In 1901 he resigned to take the management of a mining property in South Dakota. In the autumn of 1902 he resigned this position and under an engagement with the Cerre de Pasco Mining Company, of Peru, South America, proceeded thither and for a time was assistant engineer in the extension of the Cerre de Pasco Railway from Oroya to the Cerre de Pasco Mines. Working in this department but a brief time he was made assistant superintendent of the mines of his company. On the resignation of the superintendent of the Cerre de Pasco Mines, Mr. Abbott was made his successor and held that very difficult position until January, 1907. Leaving the employ of the Cerre de Pasco Company of his own accord, in reduced physical condition, caused by his arduous labors and the excessive altitude of the mines under his charge, he returned to the United States for a short visit to his family and parents. Returning to Peru in the summer of 1907, he was appointed mine superintendent of the Peruvian Mining

and Smelting Company, with headquarters at Morococha, a mining locality, high up on the western slope of the Andes. In the latter part of July, 1908, he left Lima, Peru, to examine some mining property located not far from the mines of his company. While on this trip he fell a victim of the verrugas fever, an almost deadly disease of the tropics, and after reaching Lima, August 8, he lingered till August 28, when, far from home and kindred, death came to his relief. Mr. Abbott's record shows that he was a man of strict integrity, honesty of purpose, a talented engineer, the possessor of heroic courage, devoted as he understood them to the best interests of his employers at all times and in the face of all obstacles. That he was so regarded by the various companies where he found employment is evidenced by the various promotions that came to him wherever he gave his service. His achievements as a mining engineer brought rare fruitage to so young a man, and his cruel fate no one can deny.

John Simon Baker.

Member Montana Society of Engineers.

John Simon Baker was born on the ninth day of June, 1873, at Mendon, Utah. Largely through his own efforts he acquired sufficient education to enter the Agricultural College of Utah, located at Logan, whence he graduated with honor in the class of 1899. During his college course he was employed by the United States Geological Survey at hydrographic and irrigation work in several localities. In 1899 he became county surveyor of Cache County, Utah, which position he held for two years. In the fall of 1900, through the influence of Prof. Samuel Fortier, a former instructor at Logan, Utah, Mr. Baker came to Montana and worked at hydrographic and topographic surveying in the department of the United States Geological Survey and became at length resident hydrographer of Montana for the same.

In 1901 he was an instructor at the Montana State College, Bozeman, Mont., and in due time was appointed assistant professor of civil engineering in that institution, which chair he held for two years. Resigning his professorship he went to Helena, Mont., and performed the duties of assistant state engineer under Mr. John W. Wade. During the past two years he was engaged in the development of several irrigation projects in Madison and Jefferson counties, Mont., residing most of the time at Whitehall.

Late in July of the present year he was stricken with a serious illness, from which he partially recovered, but the disease took a fatal turn and he passed away August 10, 1908. His burial place is at Mendon, Utah. Mr. Baker was the possessor of a rare personality. Afflicted from birth by a physical deformity which was a very great obstacle in the active outdoor work of an engineer, he endured his affliction without a murmur. His associates knew his generosity, admired his genial companionship and prized his royal gifts to them of professional knowledge. As a student, devoted to his studies, respectful to his instructors; as a teacher, enthusiastic, painstaking and thoroughly informed; as an engineer, devoted to the best interests of the nation and state, thoroughly practical in any branch of the profession requiring his service; eminently successful in the development of natural resources, he took first rank among his brother engineers. His brief professional career of less than ten years, covering two states, brought to him many successes and much deserved praise from those to whom he gave his friendship and esteem.

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BY G. W. DICKIE, PRESIDENT OF THE TECHNICAL SOCIETY OF THE PACIFIC COAST.

[Delivered before the Society at the Annual Meeting, January 16, 1909.]

IN thinking over what I might say to the Technical Society at this annual meeting, I have been embarrassed by the fact that this duty has devolved upon me so often that I have already exhausted the general technical subjects that usually form the groundwork for such addresses. This embarrassment was further increased by the presence of the gentlewomen of the Society, to whom I must address myself as well as to the members. I concluded, partly for the instruction and benefit of our better halves, to air the superiority of the engineer and his work over that of all other professional men of this and all other times in the history of the world; in fact, I might take the Scotchman's toast for my subject, which in English is, "Here is to us! Who is like us? Nobody."

It is often said by those who desire to point out the dangers of our time, that our so much-lauded modern civilization is grossly materialistic, that material things have been placed above the intellectual and spiritual. After listening to such warnings against the tendency of our material advancement, one is apt to infer that other and previous civilizations were intellectual and spiritual, or, at any rate, free from the taint of being the product of the engineer; yet when one considers the origin of the word "civis," a citizen, it is naturally associated with the constructive arts.

As soon as we find in the history of the world large numbers of people collected on a restricted area, there we find that considerable progress has been made in engineering. The ground immediately surrounding such populous areas could not support them, so there was need of roads and bridges or else ships to bring them their food. The earlier civilizations in Europe began in countries with extensive seaboards, to which access could be had by shipping. Greece was largely an archipelago, and the mainland was so indented by bays that ships could penetrate into a large portion of it. Rome was not far from the sea, while Italy had the longest shore line in Europe. The ship was then the most elaborate piece of mechanical engineering to which mankind had attained, and where the ship could penetrate, civilization developed. Our own rough, unkempt ancestors gained what little knowledge they had of the arts from the ships of the Phœnicians who visited their shores in the summer. In fact, the earlier civilizations were developed by engineers just as directly as our own civilization is due to the engineer.

Fénelon tells us that, when Telemachus landed at Tyre, that city of the sea crowded with the traders of every nation, her own people the most eminent merchants in the world and the vessels in the harbor so numerous as almost to hide the water in which they floated, he gazed with unsatiable curiosity upon the great city in which all was motion and energy, men busy loading vessels, dispatching or selling their merchandise, putting their warehouses in order or keeping an account of the sums due them from foreign merchants. Turning to Narbal, the captain of the Phœnician vessel that brought him to Tyre, he asked by what means the Phœnicians had monopolized the commerce of the world and enriched themselves at the expense of every other nation.

"You see the means," answered Narbal ; "the position of Tyre renders it more fit for commerce than any other place, and the inventions of navigation are the peculiar glory of our country, for we have reduced the theories of Egyptian and Babylonian science to practice, regulating our courses by night, when we can see no landmarks, by the stars; thus we bring together innumerable nations which the seas have separated. Such are the means by which we have subjected the seas to our dominion and included every nation in our commerce. But if jealousy and faction should break in among us; if we should be seduced by pleasure or by indolence; if the great should come to regard labor and economy with contempt, and the manual arts should no

longer be deemed honorable; if public faith should not be kept with the stranger, and the laws of commerce violated; if the shipbuilding art should be neglected and those sums withheld which are necessary to make the instruments of navigation perfect of their kind,— that power which is now the object of your admiration would soon be at an end."

Telemachus wanted to know still more about this interesting civilization and the arts that produced it, so he asked Narbal again by what means the Tyreans had become so powerful at sea. To this query the captain answered:

"We have the forests of Lebanon, which furnish sufficient timber for building ships, and we are careful to reserve it all for that purpose, never suffering a single tree to be felled but for the advancement of commerce; and we have a great number of our people very skilled in ship architecture; these are the gradual product of our own country. When those who excel in such arts are constantly and liberally rewarded, they will soon be practised in the greatest possible perfection, for persons of the highest ability will always apply themselves to those arts by which great rewards are to be obtained. Our kings have bestowed rewards and honors upon whoever excels in any art or science on which navigation depends, and skillful shipbuilders are not only well paid, but treated with deference by all the people, as on their work depends the welfare of our nation."

I think the Great Teacher whom so many of us accept as the Lord and Master of the race must have known how good the king of Tyre was to the shipbuilders when He said that it would be better for Tyre in the day of judgment than for the men of his generation; and for the same reason might we not say that in the day of judgment it will be better for the lawmakers of ancient Tyre than for the gentlemen of this generation who sit for us in Washington and do nothing for the upbuilding of our over-sea commerce?

The still earlier civilizations of Assyria and Egypt were due to other forms of engineering. The civil engineer and not the naval architect was their man of power. It was irrigation that converted these countries from desert wastes supporting but a sparse and wild population into lands covered with cities and monuments that have been the wonder of all ages, showing how an intensive cultivation gradually made possible not only an immense population but also a large export trade in cereals. Egypt in later years fed both herself and Rome, so that the eastern and western civilizations became alike dependent on the civil

engineer and the shipbuilder. In our day English engineers and their work have again brought old Egypt into the family of civilized nations.

The engineer in all the many branches of his profession has been the liberator as well as the civilizer of the race. There have been certain types of civilization that have flourished in a way outside of engineering, but it was attained by the degradation of the general body of the people; those who could not fight to win were enslaved and their labor enabled their conquerors to devote themselves to the arts of civilization. Thus we find a thin layer of cream on the surface of society, but below this thin surface crust there was the desperate, never-ending struggle of the masses for life. Only a small portion could cultivate their tastes if they had any, or could enjoy books, music and pictures, and surround themselves with any comforts of life.

Civilization always starts at the top among the cream of society and gradually, if it is the right sort, works downward, the rate of its progress depending on the power of the engineer to create leisure and wealth. In the first place, as we have seen, by improving means of communication so that articles which are of little or no value in one place, by reason of their abundance, may be conveyed to some other place where they are wanted, and therefore become valuable. He also facilitates the growth of food, without which in proper quantity there can be no civilization, by drainage and irrigation, rendering the land capable of bearing crops in excess of the wants of the inhabitants.

The engineer contrived tools to increase the efficiency of handicraft, and simple machines like hand looms and spinning wheels that enlarged the scope and power of the hand. He found means in the early times of smelting ores and producing metals in small quantities. Probably the greatest achievement of the mechanical engineer for hundreds, perhaps thousands, of years was the sailing ship. By these simple achievements of the engineer mankind was raised from a state of barbarism, that practically included all men, into a high condition of civilization for quite a number of the favored ones. When we look back to the achievements of the fifteenth, sixteenth and seventeenth centuries in art and literature we are obliged to admit that in spite of all our boasted material advancement we have nothing to show in their line better than they accomplished, It is true that what they accomplished could not have been obtained without the aid of the civil engineer and the mechanic, and yet, upon

what a small engineering foundation they managed to erect quite a respectable structure of civilization.

It is difficult for us to realize that so many men could find leisure to pursue art and philosophy in those days when the only source of power was muscle, except for sailing ships. When we consider the splendid results in architecture that characterized certain periods, when religious faith was simple and men could put their life into its expression in stone to the wonder and admiration of generations that followed, we are forced to acknowledge that there must have been compensations to them for what they lacked of the concentrated power which we possess.

It was only when mechanical power was made available by the work of the engineer that a civilization really became open to the reproach of being material; and, although some of us may recognize it at times in our reflective moods and on occasions like this when such moods are enhanced by the presence of those whom, perhaps, we should rather please than advance civilization, yet every engineer ought to be proud of that reproach, for material advance means the social progress of the great mass of the people whose lot under the earlier civilizations, no matter how much we may admire some of its results, was one of continual toil and short rations.

I have often wondered why engineers have been so silent in regard to the benefits they have brought to mankind. We do not belong to a speaking profession nor can we hire speakers to tell of our wonderful works, because they don't know anything about them, and the money bag that employs the engineer that he may get more money bags does not care to let the world know who it is whose work results in more bags and, we trust, less rags.

Lawyers talk loud and boastingly of the rule and order that they have brought into the civilized life of mankind, forgetting that it is the work of the engineer that has produced the wealth of which the lawyers find business in distributing the remainder after deducting their own fee. In the olden times before the engineer created values out of what was considered useless material, and the things valuable were all in the hands of a few fighters strong enough to take and to hold them, and the Highland plea that "the stoutest head, held longest out" was the law, the lawyer's time had not come. In fact, the engineer has made the lawyer possible, and he should be ready to acknowledge it with thankfulness.

The preachers proclaim the blessings that come to mankind and the civilizing power of the religion that they teach. The

clergy as a profession is perhaps the oldest of all professions and has no doubt done much for the social, moral and intellectual progress of mankind. The first preacher, however, of whom we have any record, failing to accomplish anything as a preacher of righteousness, saved himself and his family by turning to shipbuilding, finally disgracing himself by becoming a rancher, as some shipbuilders that I know have been forced to do here. It is surprising to me that the engineer and the clergy do not get closer together than they do in our day. There was a time in the history of the Church when the greatest works of the engineer and architect were dedicated to her service. Engineers then expressed their faith in stone work of the grandest proportions, building their lives and noblest thoughts into the best work man ever put into stone.

I think that the modern clergyman has, to a large extent, failed to recognize the engineering features of his great text-book, as it calls us engineers to worship the great Master Engineer, who, anticipating the coming of the engineer who was to be His heir upon earth and who should bear His likeness, determined that he should not lack for anything to uphold that dignity; and, proposing to give him power as well as dominion, even before the mountains were settled, when as yet He had not made the earth or the fields or the highest part of the dust of the ground, and millions of years before there was a man engineer to find it out, — even then prepared for his future use vast storehouses of material force, petrified action, preserved blocks of almightiness, whose possession should give him dominion over all the earth and make him mighty beyond any creature that had ever moved upon its surface.

This friend of the engineer, the Past Grand Master of all nature's laws and all science, carried out this plan for his future friend the engineer by planting immense forests of giant pine-tree ferns. He forced their growth by making conditions of climate more favorable to vegetation than anything that has ever since existed. Then He sent torrents of mighty rivers overflowing their icebound channels and hydraulicked out these giants of the forest, carrying their huge trunks on the flood to be entangled in jungle growth He had prepared at the mouths of these rivers. These in time He submerged to be silted over with the rock-worn soil and again He lifted them up and repeated the forest and its destruction, and this again and again He repeated, and finally put the pressure of worn down mountains upon the mass, holding it there for countless ages until the beautiful forest, the peat moss,

and the jungle were changed into hard black coal, the most precious diamonds of the world, condensed power, sealed-up dominion. What mighty things our engineers are doing for us to-day around a million altars from which there continually ascends the pillar of smoke from the burning sacrifice of coal. The engineer found the key to these storehouses, and the sacrifice in our furnace altars enables him to wield at will the phantom of steam and the lightning of electricity, traveling earth and sea by a power that has bridged time and space and made him master of the world. The clergy have let the engineer, who should be their closest friend, get away from them, and have failed to see and acknowledge the great work he is doing in the civilization of the race, and are contenting themselves by deploring the materialistic tendencies of modern civilization.

The men of the medical profession in these days tell of the lengthening of life that has been the result of their noble work in recent years. Their researches into the laws that govern life and health have, indeed, been wonderful, and we cannot honor them too much for the work they have done and are now doing.

Why should engineers refrain from insisting on the fact that they also have lengthened life, not by 20 per cent., but by 200 per cent., by enabling men to do in an hour what once required days, and to compass between dawn and dark a journey that occupied their forefathers a week? The engineer has brought to the poor man pure water and cheap food. He has made books so cheap that any one may have a shelf of classics, and travel so easy that seaside and mountain glen are no longer sacred to the rich. The work of the engineer may have made the rich richer, but it certainly has brought within the reach of the poor comforts of life and opportunities of culture beyond his reach fifty years ago, and the engineer who works largely for the good of his fellow man, with small recompense to himself, has the consciousness that his prosaic tasks have another character than that of money making, which enables them to rank with the more lauded achievements of the statesman and the philanthropist for the benefit of humanity.

Happiness and the very best things of life cannot be produced by engineering or mechanical means. The material things of life require the modifying power of other teaching to produce a new and better order of manhood, that will know and feel, that

> "To matter and to force the all is not confined;
> Beside the law of things is placed the law of mind.
> One speaks in rock and star, and one within the main;

In unison at times, and then apart again.
But tell of One who brought us hither
And holds the key of whence and whither.

" The sequences of law we learn through mind alone;
We see but outward forms, the Soul the one thing known.
If she speaks truth at all, the voices must be true
That give to visible things their laws and honor due.
But tell of One who brought us hither,
And holds the key of whence and whither.

" God in his science plans what no known laws foretell,
The wandering stars and fixed alike are miracle;
The common death for all, the life renewed above
Are both within the plan of that all-circling love;
The seeming chance that brought us hither
Accomplishes his whence and whither."

The onward march of progress clearly defines the growing interaction between our work and our social habits. Our moral and spiritual aspirations are also mixed up with our every-day toil and mark the line of development along which we must advance to reach our ideal of complete manhood. History shows that there is a close connection between the industry of a country and its progress in freedom both physical and spiritual. The civilizing forces of life increase with its material comforts. Most of the flourishing centers of population owe their origin to the humanizing influence of industrial science, and side by side with every advance in science there has been progress in civic legislation, in municipal enterprise, in social and intellectual peace and well being. Civilization increases wherever the mechanical arts flourish provided the people do not lose their love for higher things.

The engineer cannot create mental progress. He can and does produce wealth and renders leisure possible, but it rests with those who enjoy these blessings to decide what use they will make of them, for we must not forget that " a man's life consisteth not in the abundance of the things which he possesseth."

[NOTE. — Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by May 15, 1909, for publication in a subsequent number of the JOURNAL.]

ELECTROLYSIS OF REINFORCED CONCRETE.

By A. S. Langsdorf.

[Read before the Engineers' Club of St. Louis, October 7, 1908.]

The possible corrosion of the steel reinforcement of concrete structures is a matter that must appeal strongly to engineers in view of the constantly increasing use of this kind of construction. The subject in general has received considerable attention, but mainly along the lines of the effect of atmospheric action. Some experiments have been made to determine the electrolytic behavior of reinforced concrete, but thus far not on an extensive scale. Probably the most notable published work in this direction is that of Mr. A. A. Knudson, of New York, whose results are to be found in the Proceedings of the American Institute of Electrical Engineers of February, 1907; this appears to be the first account of an experimental investigation of the subject.

The experiments here described were carried out, under the direction of the writer, during the winter and spring of 1908, by Mr. M. M. Glauber, at that time a senior student of electrical engineering in Washington University. The work was undertaken as a graduation thesis and was very carefully done; its general plan was an amplification of that adopted by Mr. Knudson.

The tests made by Mr. Knudson were two in number. In the first test, three specimens (Nos. 1, 2 and 3, respectively) were made by embedding 2-in. pipe to a depth of 8 in. in a mixture of equal parts of cement and sand; the kind of cement is not stated, but from the context it appears to have been a Portland cement. The mold was an ordinary metal pail, so that there was a thickness of between 3 and 4 in. of concrete all around the pipe. The bottom of the pipe was closed by a water-tight plug. The specimens were then placed in water, No. 2 in fresh water and Nos. 1 and 3 in sea water. Specimens 2 and 3 were then connected in series and a steady current of 0.1 ampere was passed through them from a storage battery, the current entering through the pipe and leaving through the concrete. Specimen No. 1 had no current through it, in order to compare its condition with that of the others at the end of the test. The test was continued for a little over thirty days, current being on continuously.

The results showed an unexpected deterioration of the concrete, large cracks appearing in it. There were also strong evidences of electrolytic action on the pipes, a layer of rust having formed upon them which extended into the concrete, especially on the walls of the cracks; pitting of the pipes was very noticeable, and there was an appreciable loss of weight.

In the second set of tests two blocks (Nos. 4 and 5) were made, similar to the other three except that Rosendale cement was used. The test run was again continued for thirty days with the current constant at 0.1 ampere. The results were similar to those of the first test, except that No. 4 (in sea water) showed greater electrolytic action, a hole 1 in. by $\frac{3}{8}$ in. having been eaten clear through the pipe. In the first test, Specimen No. 1, in sea water, but without current, was absolutely unaffected. A sledge hammer and chisel were required to break it open, and the pipe was clean and bright. In all the other specimens the concrete became soft and crumbly, so that in places a penknife could be easily thrust into it.

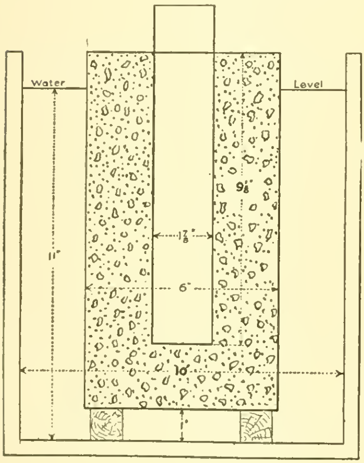


Fig. 1. Construction of Specimens.

The tests made at Washington University were also divided into two parts, but twelve specimens were used in each part. All of the specimens consisted of $1\frac{1}{2}$-in. pipe embedded to a depth of $9\frac{1}{8}$ in. in a 1 : 3 : 5 concrete, made rather wet and thoroughly tamped. The cement was Red Ring brand (made by the St. Louis Portland Cement Company) and the aggregate was crushed limestone. The thickness of concrete all around the pipe was 2 in. The specimens, after aging for about fifty days, were placed in 6-gal. glazed earthenware jars, raised above the bottom by wooden blocks, and were immersed in fresh water to within about 1 in. of the top of the concrete; fresh water was added as necessary to replace loss through evaporation. Fig. 1 shows the details of the specimens.

In the first run, eleven of the specimens were then connected in series and a current of 0.05 ampere was passed through them, the twelfth specimen being without current. The run was con-

tinued for seventy days continuously. (It will be noted that in this test the current was only half that used by Mr. Knudson, and the run was more than twice as long.) All of the pipes were weighed before embedding them in the concrete. At the end of each week one specimen was removed, broken open, and the pipe cleaned and reweighed, with the results shown in Fig. 2.

In the second run, which continued for thirty-three days, the specimens were connected as before, but the current strength was raised to 0.2 ampere. The curve showing loss of weight in

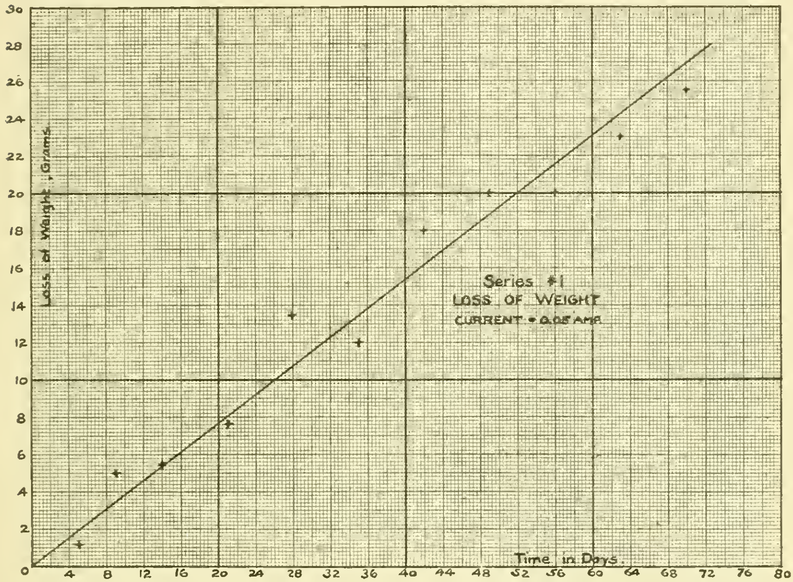


FIG. 2.

this case is shown in Fig. 3; during both runs, readings of the drop of voltage around the specimens were taken at regular intervals. The apparent resistance per specimen, calculated by dividing the volts per sample by the current, varied in the first run from 660 ohms at the start to about 1 200 ohms at the end; in the second test it changed from about 50 ohms at the start to about 500 ohms at the end. Mr. Knudson found an apparent maximum resistance of from 300 to 400 ohms per specimen, but differences in this respect are to be expected because of variations in the density, or porosity, of the samples. It is to be understood that these resistances are apparent only, for they include the effect of a very considerable polarization.

Fig. 4, 5, 6, 7, 8, 9, 10, 11, are reproduced from photographs of the specimens after their removal from the circuit, and are self-explanatory. They show very clearly the large radial cracks that formed in the concrete; and some show also the flaky white deposit that formed on the outside surface. Lack of time prevented making an analysis of this deposit, but this will be done in a further series of tests.

The softening of the concrete observed by Mr. Knudson was confirmed in these tests, but it was not so marked as reported by

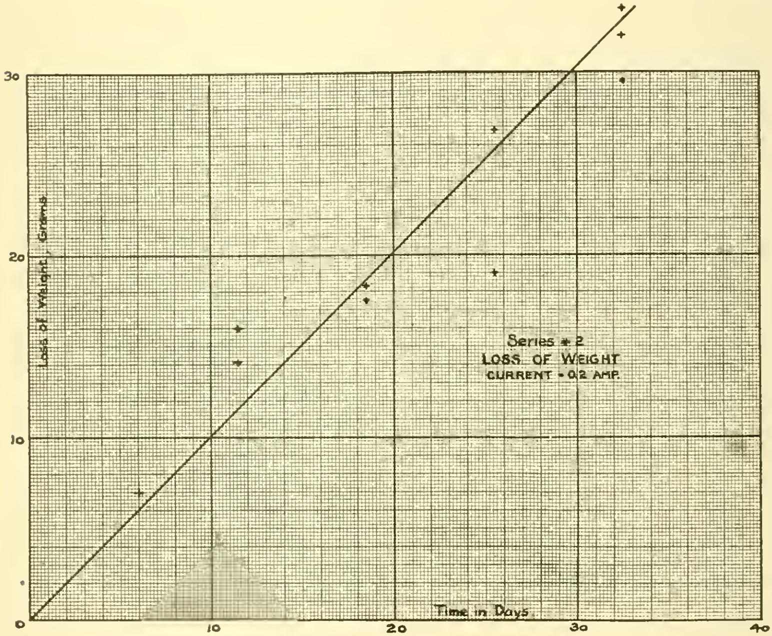


FIG. 3.

him, probably on account of the different mixture used. But the electrolytic action on the embedded metal was very strong, as shown by the photographs and by the curve of loss of weight. Whereas the specimens not subjected to the current remained clean and bright, the others developed a coating of rust whose thickness increased with the duration of current flow, and in all cases where cracks developed a coating of rust was deposited on the walls of the cracks.

The cracking of the concrete may possibly be explained by the fact that the layer of rust is of rather loose consistency, so that its density is less and its volume greater than that of the original

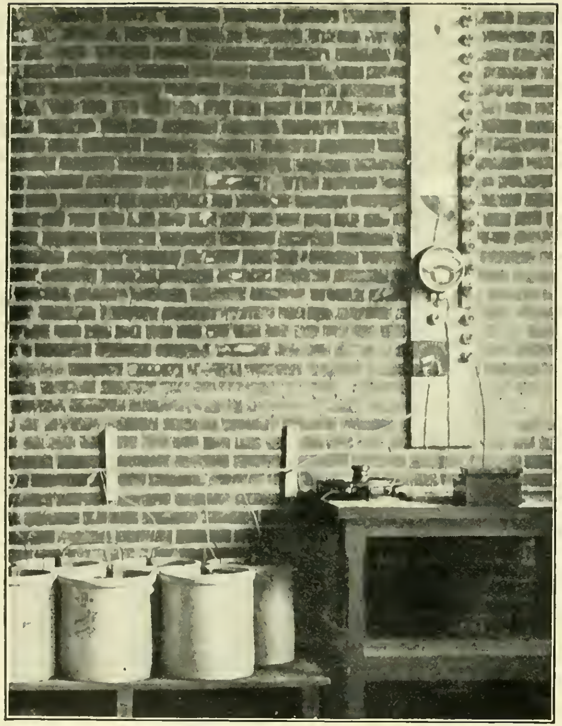


Fig. 4. Arrangement of Apparatus.

Fig. 8. Radial Cracks. Second Series. Specimen 1x had No Current through It.

Fig. 5. Showing Radial Crack partly covered by White Deposit. First Series.

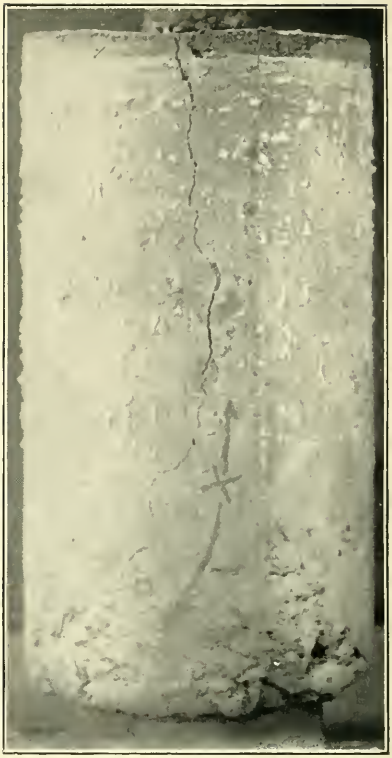


Fig. 6. Showing Radial Crack, Deposit removed. First Series.

Fig. 9. Rusty Deposit around Pipe. Second Series.

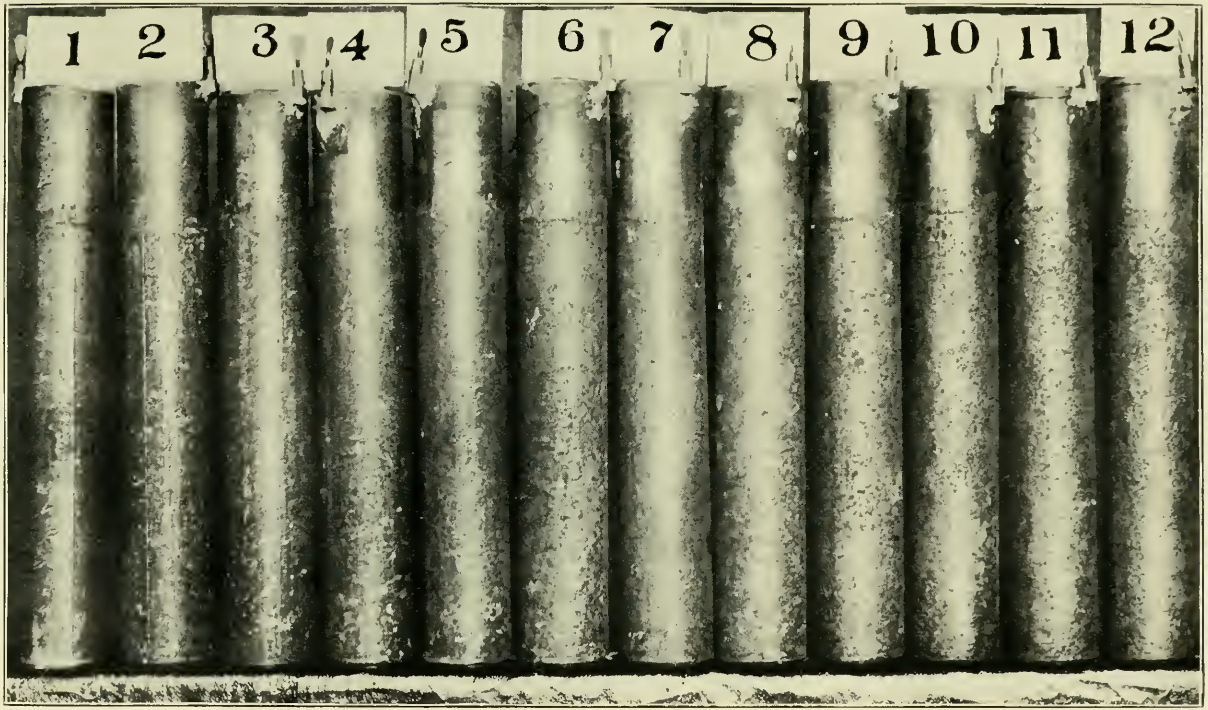


Fig. 7. Showing Progressive Pitting of Pipes. First Series.

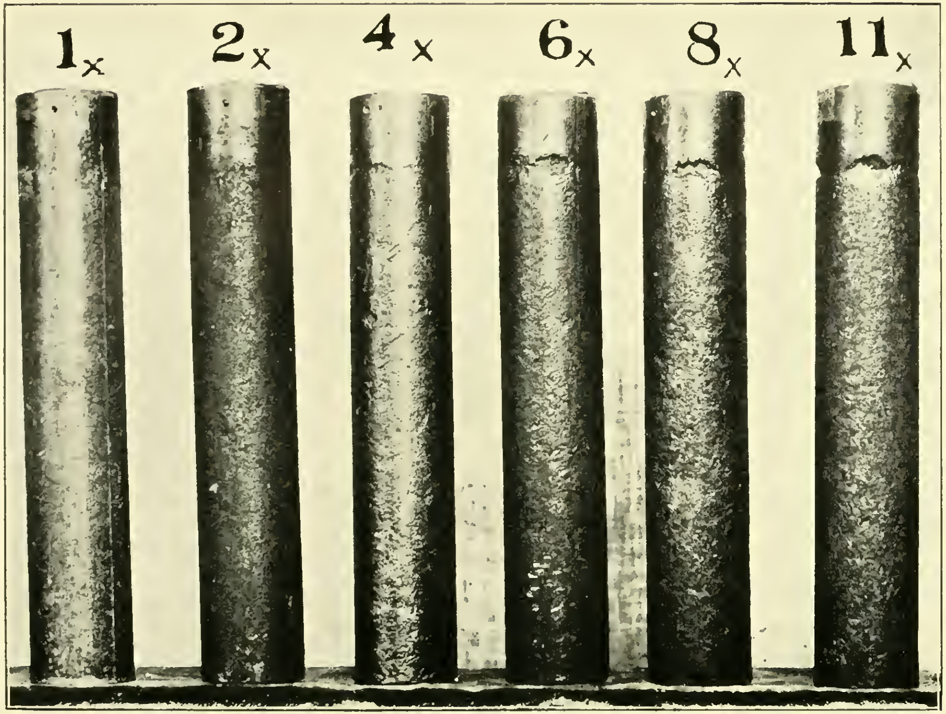


FIG. 11. PITTING OF PIPES. SECOND SERIES.

FIG. 10. TOP VIEW OF RADIAL CRACK. SECOND SERIES.

material, thus giving rise to a bursting force. The fact that the cracks are mainly radial seems to support this hypothesis.

Mr. Knudson's results, as well as those here described, indicate quite clearly that great caution must be used in the construction of reinforced concrete structures where the conditions are similar to those of the tests; such, for example, as might be found in the case of bridge abutments or concrete sewers in the neighborhood of grounded railway circuits. Further information is needed as to the extent to which the reinforcement of such structures, when buried in damp or wet earth, may become part of the return circuit of trolley lines; and also to determine the insulating effect of waterproofing ingredients in the concrete. It is the intention of the writer to take up these subjects in a further investigation, and it is to be hoped that others will also undertake the study of this important subject.

[NOTE. — Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by May 15, 1909, for publication in a subsequent number of the JOURNAL.]

HYDRAULIC TABLES.

By Joseph H. Harper, Member of the Montana Society of Engineers.

[Read before the Society at Great Falls, Mont., January 9, 1909.]

It is now nearly two years since I began the computations required for a set of Hydraulic Tables, with a view of having them published in pocket form should the completed work seem to warrant my doing so. For the past twenty months I have devoted all my available time to their preparation, and though the work is not yet complete it has advanced far enough for me to determine the general form and limits of the tables proposed, and I have been thinking that a brief statement of the scope of the work and an outline of the field I have attempted to cover might be of interest to some of our members.

The text that I intend shall accompany the tables is still in the formative stage, and is not likely to contain anything that is entirely new; in fact I have accepted the formulæ and all tablings employed just as I have found them, and have used those available for my purpose without change or modification.

My own work has consisted of computing a series of problems that extend in regular lines across the hydraulic field within the limits I have selected to cover, between which it will be possible to interpolate mentally for results that are close enough for most practical purposes.

The work very naturally divides itself into three parts, and the tables will be designated as belonging to Parts II, III or IV. Part II will embrace all tables that have reference to the flow of water through pipes and circular conduits flowing full; Part III, of its flow in flumes; and Part IV, of its flow in ditches and canals.

I have in mind a number of accessory tables which, together with a brief discussion of the formulæ used, will constitute the text of the work and will be designated as Part I.

A number of tables have been published to assist in computing the flow of water through the various conduits generally used, its mean velocity in feet per second and volume of discharge by direct inspection, but none of them so far as I am

informed embrace so large a field as I have attempted to cover.

There are others that give the value of certain factors occurring in the formulæ, which, if used in the proper manner, assist very materially in the solution of any given problem, and there are tables of this character that cover a larger field than I have embraced and cover it more completely than I have done. Mr. P. J. Flynn has published an exhaustive work of this character, to which I am greatly indebted for assistance in preparing the work I have undertaken; in fact, without the tables given in his "Flow of Water in Irrigation Canals," the task of preparing what I have to offer would have been manifolded many times, and its accomplishment under the circumstances I should have regarded as quite impossible. In using tables of this character some technical knowledge and much care are required in using the factors involved, and the trained engineer will often spend much valuable time in refreshing his memory before he can proceed with confidence, while the size of any volume with which I am acquainted, that fully covers the field, renders it unsuited for other than office use.

It has been my purpose to condense in pocket form a series of problems selected from every part of our ordinary field of work, so arranged that something near the cross-sectional areas required, something approaching the grade desired, and something approx mating the assumed value of roughness shall always be found, and to indicate the result for any specific combination of these factors in mean velocity in feet per second and cubical discharge in second-feet immediately apparent upon inspection, from which mental interpretations and extensions can be made with some degree of confidence.

These tables are not intended to, nor should they ever, supersede the formula, and careful computations on all important work, but it is believed that they will assist greatly in all approximations, that they will enable the engineer promptly on inspection to answer with confidence and with an accuracy that will fulfill every practical requirement the great majority of questions that are constantly coming before him.

Kutter's is regarded by the best authorities as the most reliable of our hydraulic formulæ and as more generally applicable for determining the various factors relating to the flow of water, though Bazin's is preferred by many for a large range of open channels, and D'Arcy's is favored by many, especially for closed channels and pipes of small diameter.

Kutter's formula for velocity is:

$$V=\left\{\frac{\frac{1.811}{n}+41.6+\frac{.00281}{s}}{1+\left(41.6+\frac{.00281}{s}\right)\times\frac{n}{\sqrt{r}}}\right\}\times\sqrt{rs}.$$

Those who have had occasion to use this formula for the solution of problems on an extended scale will recall the exacting nature of the work involved and can fairly appreciate any practical modifications that will simplify the task.

To quote the author very briefly, Mr. Flynn remarks "that a modification of Kutter's formula can be made . . . to give results near enough for all practical purposes to those obtained by the use of its more complicated form," as follows:

In the Kutter formula we have:

$$C=\left(\frac{\frac{1.811}{n}+41.6+\frac{.00281}{s}}{1+\left(41.6+\frac{.00281}{s}\right)\times\frac{n}{\sqrt{r}}}\right).$$

If now we call the numerator on the right-hand side of the equation K, for any value of n we have:

$$C=\frac{K}{1+\left(44.41\times\frac{n}{\sqrt{r}}\right)}$$

and

$$V=\left(\frac{K}{1+\left(44.41\times\frac{n}{\sqrt{r}}\right)}\right)\sqrt{rs}.$$

Mr. Flynn has reduced Kutter's formula for slopes up to 1 in 2 640 into the simplified form given in the above and has computed and tabled the value of K for fifteen different values of n ranging between $n=.009$ and $n=.0225$.

Mr. Flynn has used this modification of Kutter's formula in computing the tables that I have before referred to as having been used in my computations, for the existence of which I would again express my hearty appreciation.

Returning now to the scope of my own work, Part II, which is devoted to circular conduits, will contain two tables computed by Flynn's modification of D'Arcy's formula, the first for clean cast-iron pipe in good order, and the second for old cast-iron pipe in indifferent order. In each there are 40 different diameters graduated between 1 in. and 20 ft. each computed for eight

different slopes ranging from $s = .200$ to $s = .001$ for the smaller diameters to $s = .01$ to $s = .00005$ for those of larger size. In the D'Arcy formula the coefficient of roughness is used as a constant to which but two values are assigned, one for new and the other for old cast-iron pipe.

This part will also contain a table computed by Flynn's modification of Kutter's formula for 66 different diameters, graduating from 5 in. to 20 ft., with eight different slope angles, with values ranging from $s = .200$ to $s = .001$ for the smaller diameters and from $s = .00025$ to $s = .00004$ for those of larger size, while all combinations of the above-named factors, of diameter and grade, have been worked for four values of roughness, to wit, where $n = .010$, .012, .015 and .020.

The D'Arcy and Kutter tables above named will embrace 2 752 distinct problems, upon which the mean velocity in feet per second and the discharge in cubic feet per second are given.

Part III, relating to flumes, will contain 40 different sizes ranging from 4 in. wide and 2 in. deep to 40 ft. wide and 8 ft. deep, computed by Flynn's modification of Kutter with six different slope angles, ranging from $s = .100$ to $s = .002$ for the smaller, and $s = .0002$ to $s = .0004$ for the larger sizes, each combination of the above being worked for three values of roughness, to wit, where $n = .011$, .013 and .015, making a total of 720 distinct problems, for which the mean velocity and cubical discharge are both given.

In Part IV, for the flow in open channels, the tables have been computed by the modified Kutter formula and contain 60 different ditches or canals ranging from 6 in. wide and 3 in. deep to 100 feet wide and 8 ft. deep, with six slope angles ranging from $s = .100$ to $s = .002$ for small ditches to $s = .00025$ to $s = .0000625$ for the larger canals, with all combinations of the above worked for four different values of roughness, to wit, where $n = .017$, .020, .025 and .030, making 1 440 distinct problems, for which the mean velocity and second-feet discharge are given.

The tables in Parts II, III and IV above mentioned will contain a total of 4 912 problems completely worked, while each part will contain a supplemental table giving the value of $\sqrt{r}$ for all the sizes worked and many in addition, which will assist greatly in making accurate interpolations and extensions for a large number of sizes in addition to those given in the main table.

The Flynn modification does not, of course, give the exact result obtained by the formulæ, but over a large part of this work the difference is so slight as to be entirely negligible; in 70

per cent. of the problems the difference is believed to be less than 2 per cent.; in 90 per cent. it is probably less than 5 per cent., and while on the extreme limits where one factor strongly dominates, the difference may be greater, it is believed that every problem worked will be within 10 per cent. of the result obtained by using the formula without modification.

The principal advantage of this computation will consist in bringing a series of problems from the entire field, arranging them in orderly and proper sequence and reducing the whole to pocket form. It is not intended to take the place of larger works but I think should occupy a field of its own to the exclusion of none. I can at least with all confidence say that I should have found such a collection very convenient and of great assistance in my own practice.

[NOTE. — Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by May 15, 1909, for publication in a subsequent number of the JOURNAL.]

THE NEW YORK BARGE CANAL.

By Theron M. Ripley, Member of the Montana Society of Engineers.

[Read before the Society at Great Falls, Mont., January 9, 1909.]

Some of you expressed a desire to hear something of the New York Barge Canal, and your secretary (may he be gently dealt with) put that desire into writing with a request. The following is the result thereof.

In getting out the following, there will be a constant temptation to go into detail. Many structures and contracts on this work would furnish material for a paper or letter of interest to engineers, and particularly men doing hydraulic work; but to understand the Barge Canal, its history and general plan must be known, and the limits of this paper would be exceeded if those were thoroughly presented and no engineering problems mentioned in detail.

You Montanians (mountain men) have some of the greatest and most interesting problems to solve in the present and near future generations. Why, almost within sound of your ears, as you sit in this assembly, is the roar of one of the greatest undeveloped water powers in the world.

In taking up this subject now it would not be fair to begin way, way back, most to Noah, say, and try to prove the desirability of water transportation. That desirability is very liable to depend upon such conditions as the men, the materials, the place, the time, etc., etc.

It will be far enough back to start near the date of the building of the first canals of New York state and then come down the years with a downstream speed and no lockages, at least until we enter the Barge Canal. One cannot appreciate the magnitude of the present work without some knowledge of what preceded it, both as to physical and political conditions.

The history of the canal system is almost a history of the state since the early 1820's. Work and legislation relative thereto have touched, in greater or less degree, every state department. The canals, with their connecting and connected rivers and lakes, touch by far the greater part of the commonwealth. Along the main line, the Erie, is situated, like golden

beads upon a silver thread, the proudest line of cities and towns in the United States.

The spinning of this thread was not begun or finished excepting as are works of like and lesser magnitude. From its inception the scheme had its opponents, and its birth was no less a labor than that at the time it was born again. But, to the glory and honor, as well as the gain, of the state, the scheme prospered, the canal was built, it was enlarged, an abortive attempt was made to again enlarge it; and, lastly, a plan was adopted and is now under way to construct a waterway undreamed of a generation ago; a waterway to be navigated by 1 000-ton barges, with locks large enough to pass one of 2 500-ton burden and the work to cost $101 000 000.

New York is, and has been, preëminently the canal state, although at one time, and that time may again come, she had a close rival in the state of Ohio.

You men of the West are becoming more and more canal builders, but for other reasons than those which are urging forward your Eastern brothers. You are building canals that crops may grow; we that those crops may be the more cheaply placed in the hands of the consumer. From the Mississippi to the Pacific you are working; we from the Mississippi to the Atlantic; but each is sure to get into the other's territory. Is there an engineer among you who is willing to say that navigation of the Missouri is impossible or impractical? Not laggards and pessimists, but energetic optimists constitute the engineering fraternity, and such men will stop short of no goal east of Fort Benton in their subjugation of the Big Muddy.

The preceding may seem foreign to my subject, but remember that improved waterways breed like railroads. Do you not know that Illinois is striving for a connection from Lake Michigan to the Mississippi; that Michigan is talking of taking boats from the south end of the same lake, by canal, directly east and thereby save the long trip via the Soo; that Ohio has an organization (yes, two) of the "faithful" who are trying to bring the old canal system of that state up to standard and furnish a barge canal from Lake Erie to the Ohio River; that Pittsburg is trying to provide a waterway for itself to Lake Erie; that the Ohio River is being slackwatered its entire length and many of its tributaries are already improved, etc., etc., etc.?

Is it not a fact that the struggle for, and commencement of, work on the Barge Canal of New York state has been an assisting factor in many of these other undertakings? And this Barge

Canal will breed a deeper waterway from the lakes to the Hudson as surely as the rising sun ushers in the day.

A brief history of New York's canal system is: 1825 et al., the building of the first canals: prism, 26 ft. bottom width; depth of water, 4 ft. 1862, completed the first enlargement: prism, 52 ft. bottom width; depth of water, 7 ft. Latter 80's to 1895, an enlargement to 9-ft. depth started. Second enlargement to 75-ft. width and 12-ft. depth in land and 200-ft. width and 12-ft. depth in river channels now in progress.

The history of the present work is an immediate continuation of the 9-ft. enlargement, commonly known as the "Nine Million Work." The 9-ft. work was started without adequate preparation and under committee room appropriation. The nine millions appropriated were so thoroughly done and the improvement so undone that an investigation was soon started under Governor Black. There was also appointed, under this administration, under legislative act, the "New York Commerce Commission," to examine into the commerce of New York, — the cause of its decline and the means for its revival.

Mr. Roosevelt followed Mr. Black as governor, and continued the "Commerce Commission." This commission's final report was published in 1900, and I desire to quote several paragraphs therefrom which bear upon the immediate subject.

On page 67 is the following:

"During the last quarter of a century the commerce of the canals has steadily declined in volume and value, and this decline has been attributed by some to indicate that the canals have outlived their usefulness; that they are obsolete; that they have been superseded by the railroads, that they are no longer factors in rate making; that their future improvement and maintenance is a heavy burden upon the taxpayers of the state; and that either they should be abandoned or turned over to the federal government in order, in the latter case, that their future enlargement and maintenance may be borne by the whole country, upon the claim, by some alleged, that the benefits of New York's canals are enjoyed only by those outside the state.

"The testimony presented to this commission during the course of its investigations is conclusive against such contentions. At the terminal points, where the business conducted upon the canals originates and terminates, those engaged therein have uniformly testified to their usefulness and have presented convincing reasons why they should be further improved. This is even true of those who came to prove that the canals had outlived their usefulness and had been superseded by the railroads. The agents of railroads paralleling and competing with the

canals were the most effective witnesses in proving the comparative economy of canal transportation even with the present inadequate canal."

On page 72:

"There is nothing in the history of New York's canals to show that the people of this state are prepared to turn them over to the federal government. On the contrary, there is much to indicate that the great mass of the people are still anxious to retain, maintain and improve their own canals. One has but to go back to the year 1882 to find a vote of the people, which vote, by a majority exceeding 322 000, forever thereafter freed the canals from all tolls, accompanied by the declaration at the same time that the canals should never be sold, leased or abandoned, but that they should remain the property of the state forever. By a majority of over 115 000 the people of this state in 1894 adopted a separate amendment to the Constitution, providing for the improvement of the canals, in such manner as the legislature may direct. In the succeeding year the legislature directed by law that the Erie, Oswego and Champlain canals should be deepened throughout 2 ft. beyond their then-existing depth and that the unlengthened locks on the Erie and Oswego canals should be lengthened to accommodate the passage of boats in pairs at one lockage. By a majority exceeding 276 000 the people approved of that act at the general election of 1895. That was the last time the people had opportunity to express their will concerning the canals of this state. That the amount appropriated by the state to carry out that improvement was quite inadequate to the undertaking does not justify the abandonment of that plan of improvement, until, at least, the people have again been permitted to indicate their will with regard to their canals."

On page 77:

"It has been asserted that before the nine-million-dollar improvement was undertaken, state officers had estimated that that amount would suffice for the entire work. This commission have been unable to discover that any such estimate was ever submitted by either the Superintendent of Public Works or the State Engineer. It appears that the only estimates made by these officials are those submitted to the Constitutional Convention of 1894, and that the suggestion of $9 000 000 to complete the work subsequently undertaken by the state did not appear in those estimates. The commission understand that that amount was placed in the bill by those who drafted it — members of the several commercial bodies acting as a committee to secure legislative authorization for an improvement of the canals. It may have expressed a hope, rather than a knowledge, on the part of the friends of that measure. The bill passed the legislature and received the people's approval without having been submitted to the state officials for an opinion."

The expenditure of $9 000 000 had only sharpened the appetites of the canalers and a second commission was created. This was the Committee on Canals of New York State. The letter of appointment to this committee reads in part as follows:

EXECUTIVE CHAMBER,
ALBANY, March 8, 1899.

My dear Sir, — I am very desirous of seeing the canal policy of the state definitely formulated. . . . I have decided to ask five citizens of New York, whose reputation in these respects stands highest, to act with the Superintendent of Public Works, Colonel Partridge, and the State Engineer and Surveyor, Mr. Bond, to make the necessary investigation. . . . Last year the questions which arose affecting the canals were really two-fold in character, namely, those affecting the actual administration of the canals, and those affecting the general canal scheme of the state. As regards the former, the questions are now well on their way to solution.

The broad question of the proper policy which the state should pursue in canal matters remains unsolved, and I ask you to help me reach the proper solution.

Very sincerely yours,
THEODORE ROOSEVELT.

The report of this committee, submitted in January, 1900, contains about one hundred and fifty pages of manuscript, one hundred pages of tables and two hundred and fifty pages of opinions received by letter.

The kernel of this report is found in the second and third paragraphs thereof, which are as follows:

"*First.* That the canals connecting the Hudson River with Lakes Erie, Ontario and Champlain should not be abandoned, but should be maintained and enlarged, and that the Black River and the Cayuga and Seneca canals should be maintained as navigable feeders, but that they should not be enlarged at the present time.

"*Second.* That the project of a ship canal to enable vessels to pass from the upper lakes to New York City (or beyond), without breaking bulk, is a proper subject for consideration by the federal government, but not by the state of New York."

"After long consideration and some reluctance," this committee arrived at the conclusion that "the state should undertake the larger project on the ground that the smaller is at best a temporary makeshift and that the larger project will permanently secure the commercial supremacy of New York, and that this can be assured by no other means."

This "larger project" called for work on the Erie, Champlain and Oswego canals at an estimated cost of \$61 536 788. It also realized the inadequacy of the data available by recommending the appropriation of \$200 000 to make the necessary detail surveys and plans required to obtain accurate estimates.

This recommendation was followed, the money appropriated, \$160 000 of it used and the preliminary estimate for a 12-ft. canal, amounting to \$82 000 000, submitted to the legislature.

The report was subsequently returned to the state engineer for additions. There were then added amounts for deepening the Champlain Canal, improving the terminal harbors at Albany, Buffalo, etc., which increased the estimate to \$100 562 933.

From this amended report followed Chapter 147, Laws of 1903, known as the Barge Canal Act. This is the law, with the amendatory acts, under which the work is being done. It provides for the issuance of eighteen-year bonds for the payment of the work and, for payment of those bonds, an annual tax of twelve-thousandths of a mill per dollar of valuation for each million dollars of bonds outstanding.

Routes of the canals are as follows:

Starting from Albany, the route is up the Hudon River to Lock and Dam No. 1 near Troy. The improved Champlain Canal continues up the Hudson to Fort Edward, being in the river, improved, with the exception of the necessary cut-offs across large bends. At Fort Edward the canal leaves the river, ascends the valley of Bond Creek, crosses the low divide and follows down Wood Creek, by canalization thereof, to the south end of Lake Champlain at the village of Whitehall.

The Erie Canal improvement leaves the Hudson at Waterford, about two miles above the Troy dam, and immediately climbs the hill in order to get into the Mohawk above Cohoes Falls. This climb amounts to a rise of 169.5 ft. in a distance of 2.5 miles. This rise is made with five locks, of about 34 ft. lift each, but owing to local conditions no two are duplicates.

From this point the canal will be the river canalized to a point about 8 miles east of Utica. Thence the route is a land line up the Mohawk Valley to Rome; thence over a low summit to and through the Oneida Lake, in which about 20 miles of open water is secured; thence down the Oneida River to its junction with Seneca River at Three River Point.

The Oswego River is formed by the joining of the Oneida and Seneca, and the improved Oswego Canal will be the river canalized from Three River Point to Oswego on Lake Ontario.

From Three River Point the improved Erie Canal continues up the Seneca River a few miles to where a branch is taken out into and across Onondaga Lake, at the south end of which will be constructed the Syracuse Harbor; thence continuing up the Seneca River across the Montezuma marshes to a point near Clyde where it is again nearly upon the location of the present canal. From Clyde the new work follows, practically, the old canal to Lake Erie at Buffalo, the only exception of importance being a diversion to the south of Rochester to avoid the prohibitive expense of building through the heart of that city.

The total length of the improvement, including the Syracuse and Rochester Harbor lines, will be 442 miles.

Where the canal is in land section a rise from one level to another is accomplished by the means of a lock, with the necessary auxiliary work, viz.: spillway, by-pass, power plant, etc., as occasion demands.

Where the work is the canalizing of a stream, a dam as well as a lock is necessary to control the difference in elevation between the pools. The locks, like most structures, are alike in general design but duplicates are as rare as perpetual motion. The variation in details is limited only by the number of the structures and local conditions.

Where streams of magnitude are crossed or departed from, in long levels of land prism and at other points where it is considered that it may be necessary to control the water levels by special structure, a guard gate is to be constructed. On the Mohawk River the dams are movable with very few exceptions, the exceptions being fixed concrete dams of ogee type.

The movable dams are bridge type with Boule gates (that is, they are to be operated from a bridge). The essential features of these dams are a concrete sill, steel or wooden gates resting upon this sill and against steel frames, and a bridge over all. When the water is held by one of these dams the lower end of each frame rests against a cast-steel lug in the sill, the upper end being pivoted to the lower downstream chord of the bridge. A power hoist, resting on a track, traverses the length of the bridge for the purpose of placing and displacing the gates and raising and lowering the frames. When a dam is displaced the gates may be stored on the bridge or swung under it before the frames are raised.

These latter pivot about their upper ends and when raised lie horizontally beneath the bridge. This type is expensive but

was chosen because of its positiveness of operation and freedom from accidental breakage.

The type of fixed dams may be said to be, generally, gravity ogee. These range in height from a few feet to 80 and 90 ft., these latter being storage reservoir dams for water supply. The plans of these structures are straight and curved. The details are infinite, as no two sites present identical conditions. Also many special conditions exist demanding individual treatment.

The number and type of culverts includes box, arch and dive in reinforced and plain concrete. The different spillways and stream entrance protection range from light pavement to concrete dam. Of these minor structures the writer designed, on one contract on the Mohawk, stream entrance protection varying from 24 ft. gravity ogee dam to a protection of hand-laid riprap at the mouth of the smaller streams.

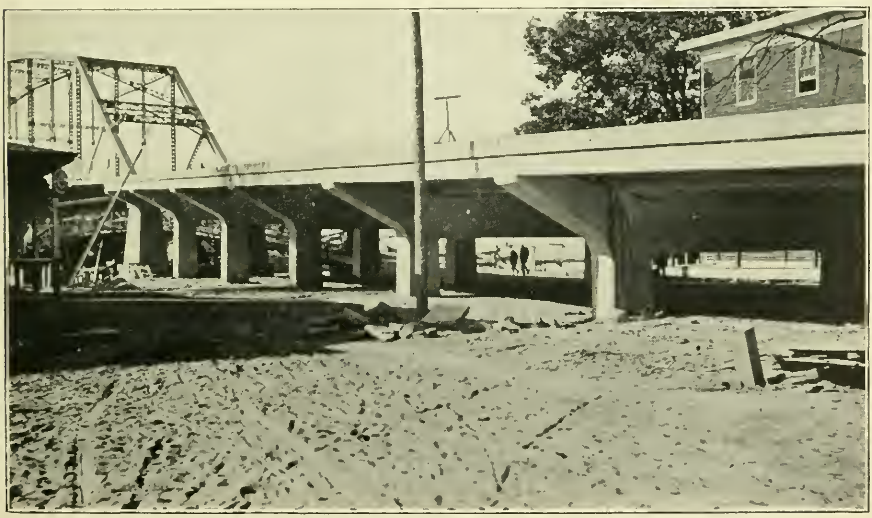
A lock was designed in which the filling was done entirely from one side, the water being taken to the culvert at the center and carried both ways to the port pipes, the emptying being accomplished by culverts around the lower gates as usual. This lock was in a peculiar situation demanding special treatment. A part of the clearing for this lock site was the removal of a block of business buildings in a large village. The excavation for it was in trap rock very difficult of removal. Another lock a few miles distant on the same contract is founded on piles. The next design was that of four locks to replace small, existing ones on a lateral canal. This was a proposition of designing to old dimensions with modern ideas of operation to be fulfilled as nearly as possible.

These designs are mentioned merely to give some idea of the varied scope of the work in detail. If you will consider that the structures are to be located at frequent intervals along a distance of over 400 miles; that they are to be constructed in rivers and deep hill cuts as well as on 50-ft. embankments; that whole villages are wiped off the map, and others cut in two; that thousands of property owners are affected from slight damage to confiscation; that some water powers are destroyed, others created and many damaged or improved (one suit is now being tried in which the plaintiff is a hydro-electric company of this city in which damages are asked to the extent of more than $3 400 000), you will grasp the fact that the problems are varied and many.

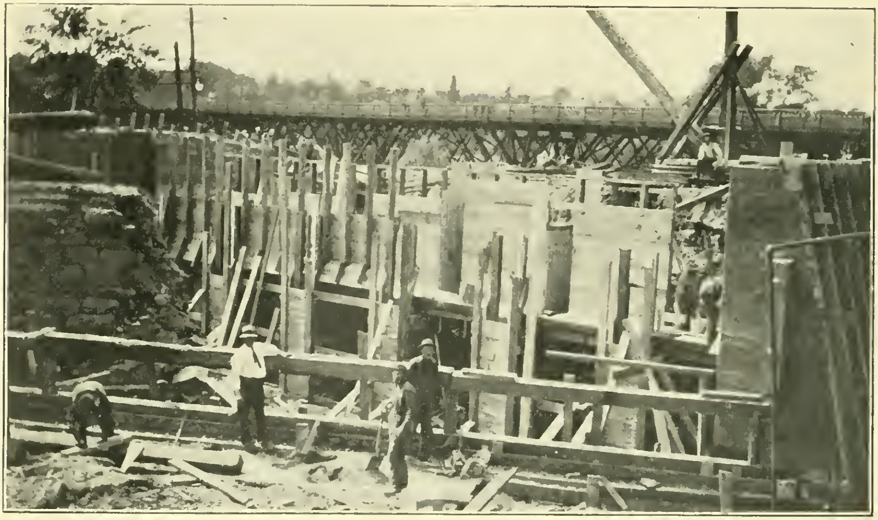
Contract 10 in this residency contains a few interesting points, and a general description of it will suffice as an illustra-

A Bad Place to Build a Long Cofferdam.

A February Accident. After this Pit was Pumped out the Ice had to be Excavated in order to Relay the Track.



Typical Bridge with Concrete Approach for an Important Location.



Building a Set of Headgates.

A Set of Headgates just Completed.

tion of the classes of work to be met, aside from dredging. This latter we shall not get until Contract 39 is let.

Contract 10 is 1.2 miles long and was let for $1 126 718. The work necessitated is for the purpose of getting around the falls and rapids in the Oswego River at Fulton, at which point are now located two dams, and at each end of these dams are manufacturing plants which use practically all the normal flow of the river not used by the present 7-ft. canal. (More would be used if it were available.)

Each of these dams gives a head of about 12 to 14 ft., but below the lower one are rapids about 1 500 ft. long. Both dams are ashlar masonry and the lower one has a timber apron.

In order to eliminate a large amount of dredging above the upper dam it is to be raised 6.2 ft. by entirely enclosing it in solid concrete with an ogee face. The lower dam is to be raised 3.2 ft., but, owing to the necessary removal of the old timber apron, and in order to reduce the cost, this covering of concrete will be hollow on the downstream side, reinforcement being used where necessary. Owing to these dam raisings, five sets of new head gates must be built (two are now completed), adjacent walls raised and, in one case, a forebay in connection to an existing headrace built a distance of about 500 ft.

The upper dam will be passed by a lock having a low pool lift of 19 ft.; the lower one by a lock having a lift of 27 ft. The gates will be mitered and will bear against an oak sill and steel hollow quoins set in the concrete walls. For filling the locks, a culvert is provided in each side wall. The water will enter above the upper gates, pass around these through balanced valves located in the upper thrust walls and thence dropped to the grade level of the lower pool; from this elevation it will pass by port pipes to the lock chamber. In order to empty the lock these upper valves will be closed, similar valves in the lower thrust walls opened and the water allowed to pass out around the lower gates. Power for operating gates, valves, capstans, needle beams, lights, etc., will be supplied by a hydro-electric plant located on the upper lock. In order to unwater the locks, for repairs, etc., a pivoted needle beam will be provided at each end of each lock. When not in use the beam will rest in a recess in the side walls just outside the gates and the needles will be stored near by; when needed the beam will be swung across the opening, its free end resting in a small recess provided, the needles put in a position with their lower ends

resting against a concrete sill, the necessary closing material deposited outside and the lock pumped out.

The two locks are 3 000 ft. apart and the docking wall is continuous between them. Below Lock No. 3 (the lower one) it is necessary to carry the canal separate from the river until below the rapids. In order to accomplish this a retaining wall, known as the "river wall," extends from the river side of the lock downstream a distance of 1 500 ft.; thence a dyke, built of rock spoil from the prism excavation, heavily riprapped on the river side, extends to and across a small low island, a distance of 2 000 ft. farther downstream.

The approaches to each lock are faced with concrete walls and enough docking room is provided for the easy manipulation of lines, etc.

For about half the distance between the two locks the terreplein or berm, of which the wall forms the outer edge, will be wide enough for docking purposes for the city. From this dock a macadam road will lead to the street above. Cast-iron snubbing posts will be placed at convenient points on the lock walls and back of the docking walls.

This contract contains thirty-five "items," the principal ones being: 475 000 cu. yd. excavation at $0.86 per cu. yd., and 90 000 cu. yd. second-class concrete, at $6.40 per cu. yd.

These items cover channeling, macadam, sawed lumber, wash wall, rip-rap, vitrified pipe, paving, cast iron and steel, structural steel and reinforcement, head gates and hoist, etc.

Excavation is not classified on any contracts. On Contract 10 about one half is rock and the remainder earth, hardpan and loose rock. The absence of classification saves much labor for the engineers and eliminates an endless amount of argument with the contractor.

Second-class concrete is a 1 : 2½ : 5 mix, and broken stone must be used. All of this stone has to be shipped in, as the local red sandstone is too soft.

The total amount of work let to December 1, 1908, based on contract prices, was about $35 000 000, divided between thirty-six contracts which range in value from $22 449 for an isolated bridge to $3 391 834 for a long dredging and dry excavation proposition which extends from the west end of Oneida Lake down the Oneida and up the Seneca rivers, a total distance of about 42 miles.

The organization of the engineering department is, in the main, as follows:

State engineer, special deputy state engineer, three division engineers, resident engineers, assistant engineers, levelers, inspectors, rodmen, chainmen, axmen, office assistants and laborers.

Preliminary surveys, investigations and maps are prepared by the resident engineers and forwarded to the division office or direct to the special deputy state engineer's office at Albany. In the latter are prepared, practically, all the contract drawings. An advisory board of five, appointed by the governor, is a consulting board for the state engineer. The Canal Board, comprised of the six highest elective state officers excepting the governor (this includes the state engineer and the Superintendent of Public Works), must approve all plans.

The contracts are advertised and let by the Superintendent of Public Works, but before that can be done the plans are signed, on title page, by the state engineer, the chairman of the Advisory Board, the Superintendent of Public Works and the secretary of the Canal Board. Prior to this each sheet of the contract drawings has been signed by the special deputy state engineer.

After the letting, sets of plans and specifications are sent to the resident engineer, who in turn furnishes the necessary sets to his assistant engineers, who are immediately in charge of the contract.

Estimates are made monthly for all work done. Six copies of the same leave the residency office (on this division) not later than the second of each month. Payment is made upon these estimates to 90 per cent. of the full amount.

There had been done up to November 1 of this year $7 567 303 worth of work. The work is just nicely started, although three or four locks on the earliest contracts are nearly completed. Next year should see a large increase in the amount of work done.

[NOTE. — Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by May 15, 1909, for publication in a subsequent number of the JOURNAL.]

HIGH-WATER MARKS.

By Francis W. Blackford, Member of the Montana Society of Engineers.

[Read before the Society at Great Falls, Mont., January 9, 1909.]

Two years ago there occurred on a piece of railway work upon which I was engaged a case of extreme high water, which was unexpected, and from an unusual cause. The rise in the river was unprecedented and covered our railway grade with sand and gravel to a depth of from ten to fifteen feet for half a mile in one place, and completely eradicated it in others, eroding the sides of the gorge and destroying all evidences of the roadbed in places where it had been completed in thorough cuts of solid rock.

Upon examining the same stream and gorge below and above the place where this destruction took place, I found unmistakable evidences that the same thing had occurred in several places within recent geologic time from the same cause and with even more marked results. Notwithstanding I had passed over the country and through this same river valley or cañon several times, I had not noticed the especial topographic features formed by similar inundations. In most cases they were overgrown with trees many years old, or with underbrush, but they were easily seen when looked for, and occurred at the mouth of most of the tributaries of the main river.

I am writing of the western slope of Mexico, at a point nearly directly west of Mexico City, and distant from the Pacific Ocean, more or less, seventy miles. On the night of October 3, 1906, there occurred a rainfall of unusual severity, even for this semi-tropical region. The Tuxpan River, a stream about the size of the Jefferson, was in flood, but the rain seemed to have been greater or to have had greater effect upon the barranca (tributary) Itentique than elsewhere. This barranca drains the east slope of the active volcano of Colima and its extinct neighbor on the north, called Nieve, both of which rise to an altitude of nearly fourteen thousand feet.

The waters came down this barranca in tremendous volume, laden with earth, gravel, bowlders, timber and other débris,

After the Flood in the Tuxpan River and the Barranca of Itentique, in October, 1906, Mexico.

After the Flood in the Tuxpan River and the Barranca of Itentique, in October, 1906, Mexico.

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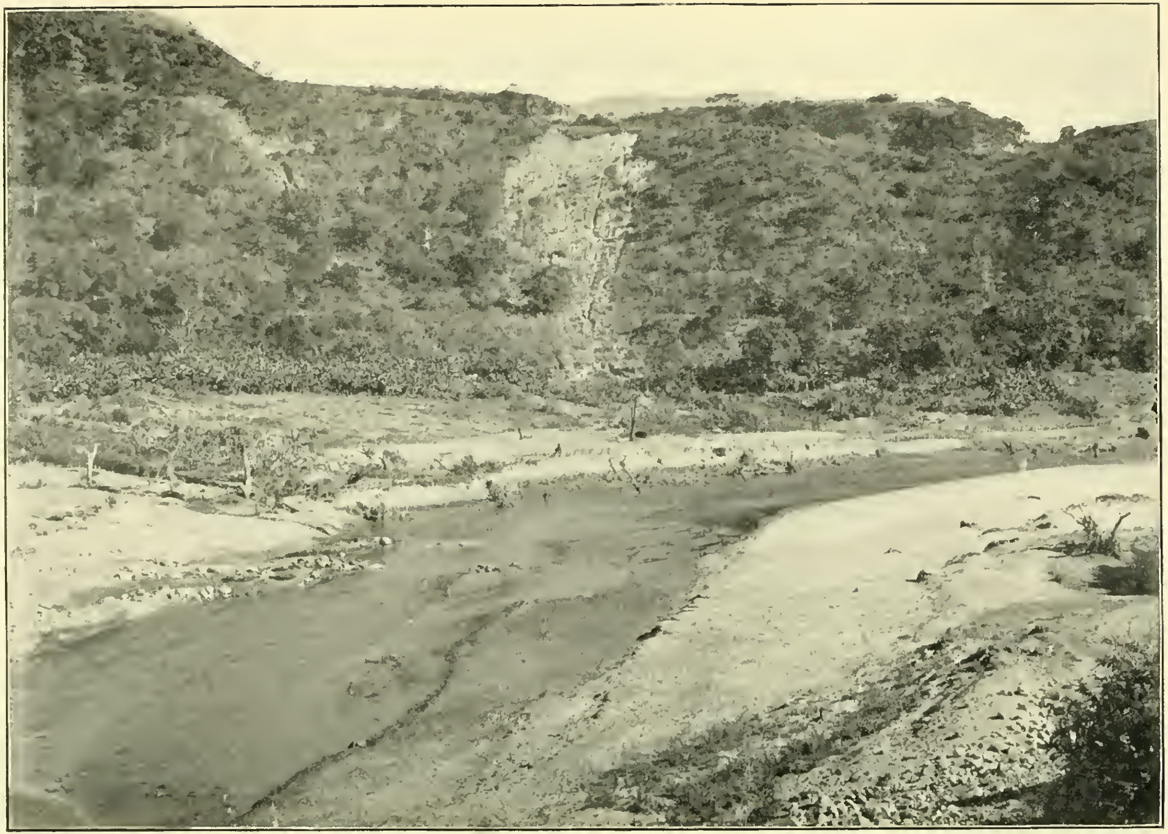

After the Flood in the Tuxpan River and the Barranca of Itentique, in October, 1906, Mexico.

quickly filled the little valley of approximately eighty acres in extent at its mouth and made a dam across the Tuxpan River about sixty feet in height. This material extended up the river more or less one thousand feet and down two or three times that distance, or to a point where the valley terminated in a narrow gorge. The waters of the Tuxpan River backed up behind the dam, which subsequently broke and water and débris went roaring down the cañon, doubtless in a manner similar to the Johnstown flood, carrying everything before it, and eroding the sides of the cañon and washing away the railway grade, even where it was in solid rock, as aforesaid. The water backed up to the iron railway bridge about two miles above and piled driftwood against the spans, and when it subsided it carried the spans with it, depositing them in the bed of the stream several hundred feet below.

All of this occurred between dark and daylight of a very dark, rainy night, and nobody saw it. Those who camped on the hillside opposite the dam say they heard a great roaring in Itentique for about three hours. The next morning both the Tuxpan and the Itentique were at their usual high-water stage, but the topography of the neighborhood was materially changed. The Tuxpan had cut a channel through the dam, with vertical sides, about sixty feet high. Itentique likewise had cut its channel about sixty feet deep through the material it had brought down and piled up only a few hours before. With the exception of these two little cañons, the valley of about eighty acres remained filled to a depth of from thirty to sixty feet.

I measured some of the granite bowlders that had been brought down and estimated the largest at about 400 tons. The débris from this flood was in evidence in the cañon for a distance of 15 miles, as far as the railway line followed the river, and as far as my observations extended. The larger bowlders were, of course, deposited first, the finer materials being carried further. I estimated the material deposited in the dam and in the little valley at about 10 000 000 cu. yd.; doubtless several million more were carried down the Tuxpan River.

We cannot always build against such contingencies; sometimes it is impracticable. It is well enough, however, to know that the ordinary high-water marks, and even the testimony of the proverbial "oldest inhabitant," are not infallible evidences of how high the water will rise. In any mountainous country such a thing as I have described may take place, and

death and destruction result. Itentique or any one of the several barrancas emptying into the Tuxpan may do this same thing next rainy season, or it may be centuries before they will do it again; who knows?

The four photographs herewith show some of the features described.

[NOTE. — Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by May 15, 1909, for publication in a subsequent number of the JOURNAL.]

ASSOCIATION OF ENGINEERING SOCIETIES.

Organized 1881.

VOL. XLII. MARCH, 1909. NO. 3.

WHY ENGINEERS DO NOT TAKE MORE PART IN GOVERNMENT.

[Addresses made at meeting of Boston Society of Civil Engineers held at Bretton Woods, N. H., July 4, 1908.]

BY JOSEPH R. WORCESTER, PRESIDENT OF THE SOCIETY.

ON this occasion, when we engineers are combining the celebration of the sixtieth anniversary of the foundation of our Society with that of the one hundred and thirty-second anniversary of the Declaration of Independence of our country, it is appropriate for us to pause a moment to consider whether we have assumed our full share of the duty of supporting and maintaining the nation of which we are so proud. An impartial review, with the honest intent of looking at our record through the eyes of an outsider, may be wholesome, even if not entirely flattering to our self-respect.

We think that none will deny that engineers as a rule are "good citizens," but let us think a moment what is implied by this time-honored expression. A good citizen is one who lives in accordance with the laws of the land, who pays his debts and his taxes, who keeps faith with his neighbor, who votes on election day, and who takes a moderate interest in charitable and (possibly) religious organizations. We think we may safely claim that we do this much. So, indeed, can practically every society, every trade union, every fraternal association, every class of workers in the country, and with as much justice as engineers. It is merely stating that we keep out of jail and get along without friction with our neighbors.

Should we not do more? We like to style engineering as a

profession, but do we realize what the difference is between a profession and a trade? Aside from the forced meaning of professional as the opposite of amateur, there is always implied by the word a certain superiority due to learning. The universities are tending towards the use of the term "professional schools" as those requiring a preliminary degree as a condition of entrance. Besides this educational distinction there is the ancient use of the term "profession" and "learned profession" interchangeably as meaning the same thing. Originally these learned professions were limited to theology, medicine and the law, but now, by general consent, other branches of human activity, such as teaching, writing, architecture and others, are considered professional pursuits. The distinguishing characteristics of all of these branches is that proficiency cannot be obtained without higher education. In all it occasionally happens that a natural genius rises to the highest rank without the advantage of the preliminary schooling, but such cases are exceptional and do not affect the argument. By the criterion of education, if we consider the first few years of practice as the equivalent of the last years in the professional school, engineering may be entitled to a place among the professions. But are there not other distinctions between professional and unprofessional work?

When any one is seeking professional assistance of any kind, whether legal, medical, architectural or engineering, he selects his adviser on account of some individual characteristic. He may know personally just the man he wants and he goes to him. If he has no acquaintance who would satisfy him, he makes inquiries of his friends, or he finds out who did a similar piece of work satisfactorily elsewhere, and he follows up this lead. Hence it is distinctly unprofessional to make engagements on a commercial basis; to do so assumes that professional advice is a commodity which can be dealt in in the same way that paint and cement can be selected. Are engineers quite as free from the commercial taint in this respect as are the other professions? Possibly, but certainly not as free as they should be. We are very properly indignant when ignorant town officials ask for proposals from engineers for certain work, but cases are not as rare as they should be where engineers bid against each other and advertise themselves and solicit work.

Again, is it not fair to expect from engineers as well as from other professional men a large amount of public service? Do not the advantages of higher education, superior talent and mental training carry with them corresponding duties to the

community and to the nation? The very existence of our democratic form of government is dependent upon each contributing not only of his material resources, but also of his mental powers. In this particular I fear the engineering profession has not done its full duty, and I believe we can never be to-day truly professional as long as we hold ourselves back to the position of paid servants. The feeling is altogether too common among us that the nation, the commonwealth or the city can well afford to pay for engineering assistance. This sentiment has even been expressed in business meetings of our Society more than once. The government can afford to pay for labor, for materials, for subordinate services, but it has a right to expect free contributions of thought and brain power from those who love their country and have these advantages in abundance.

It is much easier to criticise than to construct. It is a lazy habit we all are liable to fall into to read our newspapers and to sneer at politics as something others dabble in, but which we, thank God, are clear of. Should all professional men take the same attitude and leave politics to those who go into it for what can be made out of it, we can imagine the result. We sometimes have seen municipal politics reach near to this level. Fortunately our own state has never fallen so low, and the country has always been steered by some minds controlled by patriotism rather than greed.

How much part have engineers taken in this real service to the public? Of the twenty-five presidents the country has had, nineteen have been lawyers, three have been soldiers, two politicians, and only one, the great Washington, could lay any claim to an engineering training, though in his case the engineering was only an incident and it was his military ability which brought him into prominence. Of the twenty-three vice-presidents, nineteen have been lawyers, two merchants, one a politician, one a farmer, and not one an engineer.

It would be an interesting study to determine how many engineers have been in Congress or have taken part in the state government. Undoubtedly there have been some, though the writer fails to recall more than one. A hasty examination of the list of members of our Society discloses but one who registers an address as a holder of an elective office, though quite possibly there may be others who, while holding office, consider their professional title as of more consequence, at least in a list of engineers, than their political position. In the list of deceased members the writer fails to recognize any name known on ac-

count of political service. Many engineers have served and still serve as city engineers, chief engineers for commissions, even as members of commissions, but almost always in places to which they are appointed to do a certain specified work for a specified salary. Very few are chosen by the people as leading citizens to offices connected with the government. Why is this?

In reading memoirs of deceased members, one is struck with the frequency of the phrase, "He was many times urged to accept public office, but never consented." How many of the present company can say that he has never been asked to run for office and refused? Is it on account of instinctive modesty that engineers shrink from honors thrust upon them? With all due allowance for our tender feelings, I am forced to say that I believe it is frequently shirking rather than shrinking. One excuse which may be advanced is that we cannot afford the time, and, no doubt, it is often true that it would mean pecuniary loss which we can ill afford. There is no doubt, too, that in some professions, such as the law, political activity increases a man's value in his own line, while this would not be the case with an engineer. At the same time this does not seem to me to be the controlling motive in most cases. It is rather that we overlook the fact that it is a patriotic duty which we owe to our country to serve the government to the extent of our ability, even at the sacrifice of personal comfort and gain.

Let us then as a society and as individuals, on this combined anniversary, resolve to open our eyes to a defect in our previous history and endeavor to do our full share in upholding our government by giving freely of our advice, hoping for nothing in return; by encouraging and supporting men and measures which make for the general welfare; by combating openly and without fear of personal injury all forms of corruption and greed; by not refusing to enter the political field when to do so is a clear case of duty.

By George B. Francis.

After listening to the address of our President, I am somewhat at a loss to comprehend what he would have engineers do to serve their country better than they do at present. The impression which is left in my mind by his remarks is that he thinks engineers have not, perhaps, fulfilled their duty in "supporting and maintaining the nation of which we are so proud."

I am not personally satisfied that he is correct in this view, but, on the contrary, I am, on reflection, of the belief that engi-

neers taken all together have done better than the average citizen in this regard. The engineer is always an intelligent citizen or he could not be much of an engineer.

Professional men may be grouped in five great classes, as follows:

Legal, medical, clerical, art and engineering. These classes merge to some extent and contain many subdivisions. They all help to " create, support and maintain their nation " through the medium best fitted to their attainments.

The legal profession takes the lead in adapting ways and means of creating, interpreting and administering laws which regulate the relation of individuals to the government, to one another and to corporations, as well as between corporations and companies. They also conduct actions to determine disputes, responsibilities and crimes. Most of these methods of regulation are established by legislative bodies which are necessarily largely made up of lawyers, who are selected through political preferment, in consequence of which the lawyer, of all professional men, is most active in politics and most before the public eye.

The medical profession takes the lead in matters pertaining to public health, prevention of disease and restoring the ill. Investigation in matters pertaining to this profession are most profound and far reaching and *very* largely absorb the attention of the contemplative mind. The greater public service of this profession is thus performed indirectly, yet there is opportunity for some personal activity in the political or social matters of the time.

The clerical profession have under their charge the spiritual and moral welfare of the nation, and members of this profession frequently serve the nation by becoming active in supporting and maintaining public policies which conduce to mental uplift.

The profession of art includes all trained contributors to sculpture, painting, architecture, ornamentation and embellishment of whatever fabrication. In it can also be included authors, educators, journalists and diplomats. Such men of " higher education, superior talent and mental training " serve the nation with their talent and are often prominent in public spirit.

The engineering profession has a field of its own in designing and constructing the innumerable conveniences made use of by the nation. These conveniences need no enumeration in a gathering of engineers. The question under consideration is, Do we do our full share, as intelligent citizens, in promoting the

good of our country through participation in its current affairs, politically as well as otherwise?

To be capable in any profession, a man must go through long years of training, with close attention to the details which make up the characteristics of the profession which he has selected, and when he is matured it is not to be expected that he will shine in very many other callings.

A nation cannot be supported and maintained in the broadest sense until it is fairly created, and what class of men have done more in creating the practical and material as well as highly useful public things which a nation requires than the engineer? Is it to be expected that generally the work and study of the engineer will result in making him a graduated student in political economy or the science of government, a man of high rank in statesmanship, law or finance? The very nature of his work compels him to go to the bottom of the details of every subject in which he is engaged in order that the results as a whole shall be correct. This necessarily holds him to the closest attention to his engineering work and largely prevents him from branching out into large studies of matters extraneous to his chosen career. Insofar as he can share the public burdens without neglecting his engineering, I believe he does so.

He is invariably a good citizen, and, like all professional men, is more interested in the work he does than the fortune he accumulates, generally being content in this respect with an income sufficient to live decently, with possibly a moderate competency for old age. Service to the public, in the manner for which he is best fitted, is certainly not one of the failings of the engineer. Witness his efforts in solving the great problems of national advancement, such as land and water transportation, sanitary works, industrial power development and national defenses, the ramifications of which it would take hours to recite in general detail.

This nation maintains at least one school (West Point) for training men for its most important service, and the graduates of the highest standing are designated for service with the engineers.

I firmly believe that the "advantages of higher education, superior talent and mental training carry with them corresponding duties to the community and to the nation," and I further believe that engineers do discharge those duties faithfully by vote and influence, without being in politics for what can be made out of it, even if they do not often serve in the lawmaking

bodies of state or nation or become Presidents. The endeavor of the President of our Society, however, to impress on the minds of engineers that they must not hold themselves aloof from a proper personal application to the affairs of government, through all channels available, is laudable and to be commended.

By Dexter Brackett.

The speaker fully agrees with the opinion of our President that it is the duty of members of our profession to interest themselves in public affairs, especially in those matters for which the training and experience of the engineer renders his services especially valuable, and it is doubtless true that the members of the profession do not take as active a part in public matters as they should. He is inclined, however, to think that the President is not aware of the extent to which the members of this Society have given their services without compensation for the public good. Members of the Society have served as members of the state legislature, of city and town governments, of water and sewerage boards, and in all cases the speaker thinks it can be safely said with credit to themselves and to the profession. At the present time there are, to the speaker's knowledge, at least a dozen members of this Society holding such positions, and there are doubtless others of whom he has not learned.

As to the reasons why engineers do not take a more prominent part in public affairs, it appears to the speaker that one very strong reason is that the engineer's training does not tend to fit him as a public speaker, while the successful politician is in nearly though not in all cases a good public speaker. Young men having the natural ability to speak extemporaneously are more likely to become members of the legal profession than to become civil engineers, and the training of a lawyer naturally tends to give him confidence and make him a good public speaker. That the engineer should cultivate the habit the present speaker thoroughly believes, and he personally realizes the great advantage possessed by the man, be he lawyer or engineer, who can, without committing his thoughts to writing, clearly and without hesitation state his views on any subject which he wishes to present to an audience.

One definition of the word "politics" is "the administration of public affairs in the interest of the peace, prosperity and safety of the state," while another definition is "the administration of public affairs so as to carry elections and secure public

offices." The latter is too often the controlling interest of the politician.

The speaker thoroughly agrees with our President that we, as engineers, should be willing to give for the public welfare of our knowledge and experience. He believes the standards of the profession are high and that the influence of those standards on the governments of the town, city, state or country will tend toward raising the present political standards.

By Morris Knowles.

I have been led to view the subject in a somewhat different way from the other speakers, and the reason for not having anything ready in written form is that I have not had opportunity, since agreeing to discuss the question, to put down in logical order that which I wish to say; therefore my talk will be somewhat rambling and touch upon the subject in five different ways. My experience in these matters has not been extensive; some thirteen or fourteen years ago I was a member of an unsalaried municipal board in charge of water works; most of my professional occupation has been either for state or municipal governments, and recently, as a diversion from regular duties, I have been a member of two public committees, one upon "Floods" and the other upon "Sanitation."

I want to record my agreement with the President that, while many instances can be found of engineers serving either in political or semi-political offices, and without compensation, the cases are few enough to be called rare, and the interest taken in practical politics is so rare as to be considered an exception. I do believe, in the main, that if not employed by a governmental agency, the engineer, as any other citizen, owes it as his duty to be interested in practical political detail. Of course, if employed as above, his motives are likely to be misunderstood, but in this case even there are many ways in which a man's political or statesmanlike activities can be well employed, and it is upon some of these that I shall choose to touch.

First, I want to say that it has been one of the greatest pleasures to be associated in work outside of my particular professional duties in these political or governmental positions, and even in a small community this mingling with the men of affairs and with men of not such great activities, and having their own limited point of view, is broadening and helpful to a man in understanding the reasons for different beliefs and thoughts,

and helps him to assist in molding public opinion. We are commonly led to decry the intelligence and the views upon municipal problems, at least the theoretical and special ones, by the baker, the butcher and the candlestickmaker, etc., but I want to say that in my association with men of different walks of life, all of these, if given a chance, and if the subject is carefully explained, wish to study and will be glad to secure unbiased help in order to solve the problem before them.

Second. By the so-called outside activities, a man's field is broadened, and two things are true: *He who has will receive more; and the busy man does things.* Therefore, while we may think ourselves too busy and wish to have more recreation, it is not only true that the doing of more things and accustoming one's self to do things rapidly and logically enables this same one to turn out more work and help the public, but it is also true that he who continually does these things will be looked upon not only as a helpful man, but one to be intrusted with problems; greater opportunities and still greater are likely to come to him. But, beyond all this, it is our duty as citizens to aid in the uplifting of our government, both in a small way in municipal activities and in a larger way as our ability may be helpful; and it is by thus joining hands that we can do a great deal of good for the public weal. The knowledge, however, that additional opportunities may come should not lead us to consider the mercenary motives such as occasionally come to one's attention. One illustration will suffice.

In the consideration of the appointment of a certain municipal commission to investigate an important problem, one who was asked to serve upon it said, "What is this, one more of the 'Thank you' jobs? I have already done quite a little of this service and it seems as if there should be some compensation." If we look at these opportunities with this view, how can we blame others who, in their municipal positions, question, "What is there in it for me?" when asked to promote some broad public policy for the general good?

Third, to speak more particularly of political activities, there is always danger, particularly if the action be concerted, even though the man or men may not be employed in governmental office. A story that comes to my mind will probably illustrate this better than in any other way. Some time ago the question of reappointment to a certain important engineering office came up, the appointment being in the control of a small board. In due time, because of excellent service of the then

incumbent, several engineers thought it wise to appear before this board to advocate the retention of this particular man. It happens that these gentlemen were many of them officials, and most of them influential members of an engineering society. All of the steps so far were evidently laudable and the result of careful consideration and accomplished good; the next step, however, does seem to pass beyond this limit. In a short time the election for the filling of the position of member of the board was to be held. Perhaps not for value received, but more likely because of the good will and valuable public good done, it seemed to be the desire of the same engineering gentlemen to retain in office the same board members. Therefore a circular was addressed to other members of the engineering society, which, although it carefully stated that it was not done as a society or official matter, still on account of the knowledge of the previous endeavor, coupled with a knowledge of the position of the men, could not help but carry with it the impression to those who knew and to some who only surmised, that here was a use of the concerted action of the engineers for securing the employment of a man and afterward for rendering political service. Thus it is hard to draw the line where one may engage upon such activity and where one should judiciously let it alone.

Fourth. There is one way in which engineers' influence can perhaps be brought about by concerted movement and be within the limits of the proper action, and that is in the prevention of competitive bidding for engineering service upon public work, an act which would never be thought of in requesting a lawyer or doctor to give advice. Recent activities, due to the good sanitary laws in several of our states, have brought about the necessity for many public works of a special and technical nature, about which not all men are well trained. There are laws in some states that seemingly oblige public officers to secure competitive bids for all items of work and furnishing materials and services, and this, in some cases, is construed to include engineering and expert services and advice. Thus, frequently, engineers are apparently thrown into competition with one another, without a knowledge of the facts and the work awarded, without an understanding of the conditions or an appreciation of the qualifications, to the lowest bidder. This frequently leads to undeveloped and poor work. Here is an opportunity for an endeavor to secure proper legislation, and it seems as if concerted action would not be amiss or unwise.

Fifth. Civil service in engineering positions should particularly interest our profession, and it is our duty to pay attention to this. It is probable that, considering all municipal activities, over one half of the amounts appropriated by taxation are spent upon public works, either under the control of engineers or allied to engineering work. Other moneys are spent for public safety, charities, *et cetera.* Civil service has seemingly been necessary because of the political activity to overturn existing things whenever a new administration comes into power, and the fulfillment of the slogan, "To the victor belongs the spoils." Something has been required to meet the earnest belief that "a public office is a public trust," and civil service, namely, the employment of men after examination by a disinterested body, the inability to discharge without cause and the placing under the control of an independent body of wise men such employment and control, has been offered to meet this condition. But, to use an expression which has come to my mind on a previous occasion, "Civil service will never take the place of the honest endeavor of the appointing officer to secure the most capable assistants."

Civil service as now generally conducted by academic minds with theoretical training and usually administered by men who, however honest and capable, are still not those who have had to do with the hiring of men and the practical difficulties, has many times grown to be a farce. This is perhaps most apparent in the lines of work with which we are especially connected, and for the reason that engineers have not, as a rule, interested themselves in either the drafting or application of these laws. Thus we find examinations of a theoretical nature, with little attention paid to experience and training, and little opportunity for sizing up an applicant in this practical way, have brought about the filling of our positions with the men of medium or inferior grades. Men of intelligence and capacity can secure other employment without so much red tape, with a better presentation of their qualifications, without so much stress being paid to book learning, and with the knowledge that special endeavor will admit of promotion, controlled by the direct superior, rather than from some outside influence which is only controlled by some red tape of record, which does not represent the true worth of a man. There is, therefore, this general leveling downward and reducing the output of a force rather than the endeavor to excel and increase the output. Here, then, is an opportunity where engineers may direct their efforts to securing proper

legislation and also the application of wise methods to bring about a saner method of employment in the civil service.

I hope to have not tired you in these remarks, or made you think that existing conditions are all wrong, but I do agree with our President that, while direct political or detail activity may not always be permissible or wise with engineers, there are many other and broader ways in which an engineer can influence legislation wisely; and this really should be the basis of all really good political activity.

By Frank W. Hodgdon.

The position of the engineer as a specialist in this country is of quite recent origin, and has, up to within a few years, been in a great degree confined to the construction of transportation lines, which required residence in unsettled regions; and the well-educated were so few that their whole time was demanded for their work.

The early settlers were necessarily their own engineers, and it has taken generations to learn that the necessary routine engineering work could be done better by trained experts than by the people, who were following in the tracks of their ancestors. The science has required all the powers of its members to secure its material development and to prove to the people that the engineer's training was as necessary as the training of the lawyer, the physician or the minister. In the early days the minister and the doctor were the leaders, they with the lawyers being almost the only persons who had received a college education. As the social conditions changed, and education became more general, the leadership of the members of these professions has become less marked.

Another reason why engineers have not been prominent as political office-holders is their migratory life, due to the necessity of traveling from place to place in search of work. At the present time there is more stability, but even now comparatively few engineers spend the larger part of their professional life in any one community, and for elective offices a candidate generally must be well known to the electors.

I think that the President will find that many engineers in the vicinity of Boston are filling elective positions in their various communities with credit to themselves and to the profession. Within my own knowledge I might mention the present mayor of Cambridge, and in Arlington two members of the Board of Public Works, two members of the Park Commission and the

chairman of the Finance Committee. Residents of other cities and towns can probably cite similar cases.

Engineers should, as the President remarks, give of their time and experience for the public good, and in so doing should make it clear that engineering training will make as good or better public officers as legal or medical training.

By Wm. E. McClintock.

I have listened with much interest to the remarks of the President upon a subject that should interest every engineer.

I fear the President has undertaken too much if what he says is true that he never can find time to eat with us at the long table, but takes a standing bite at Thompson's. He must give that up if he intends to accept any municipal office and shine in it. I don't agree with the President as to engineers filling offices of trust. I can without any difficulty recall scores of the busy ones who have served with honor on local boards of health, public works, sewer boards and school committees. Others I know who have served in the legislature and Senate of their state.

I think, though, that the average engineer, as a rule, is too modest to enter into a political campaign, but usually when he does he is easily elected to the office which is seeking him. And he fills whatever office he occupies, only getting through when he says " Enough."

I think in the little group where I dine off and on some seven or more engineers have served for years as church treasurers.

One thing delights me in connection with the civil engineer in office — and in office where he has the direction of the expenditure of millions of money, I never knew of one who was dishonest to his trust or was connected with graft or took a commission, or to whom even the finger of suspicion has been pointed. I say this after having had close relations with scores of the craft.

Modesty forbids me to speak much of myself, but I have just accepted a position of trust as chief executive of the stricken city of Chelsea, as the head of a commission to govern a city and attempt to rebuild it. You of course know what happened in that little city on April 12, when the fire fiend swept over three hundred acres of a closely built-up city, destroying over twenty-seven hundred buildings and turning sixteen thousand people out of their homes. You may be interested to learn that amongst those buildings were eight schoolhouses, two engine houses, a

city hall, public library and city stable plant.* The problem is to build city buildings that will give confidence in the future and cause people to rebuild their stores and their houses, their club houses and churches. And, Mr. President, we are going to do it. It may look dark just now, but there are indications of a beginning, and if enthusiasm counts for anything, the city has got to grow, because there are two engineers on this board with enthusiasm and enough to spare.

I think I have said enough to satisfy any one that the President was not correct when he said that engineers did not do their share in public affairs.

CLOSING REMARKS.

By J. R. Worcester.

After hearing the able remarks of those who have taken part in the discussion, the speaker feels properly rebuked. He is much pleased to have been able to draw out the references to the work of engineers in the public service, and would not for a moment think of controverting any of the testimony given as to the value of such service. Too much credit cannot be given to those engineers mentioned, nor to the speakers themselves for the magnificent work they have done, and there is not the slightest doubt of the important part played by the profession in influencing and supporting our Massachusetts commissions in this honorable record, of which we are justly proud.

At the same time, is it not possible that this commendation is due to the few rather than to the profession as a whole? Brilliant exceptions to a rule may serve as rays of bright light to dazzle the eyes and make the general darkness more pronounced. The lesson of the discussion is not for those older members of the Society who have already done their part and feel the legitimate reward of their labors in a well-earned satisfaction, but rather for the younger members who have their future before them. By them, the speaker trusts, the subject will not be dropped, but will be pondered and remembered, and, if so, will in time bear fruit.

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* February 24, 1909. The city stable is finished, the central fire station is finished and occupied, one other engine house is almost ready for occupancy. A 24-room school and a 20-room school building are partly done, and plans for library are made. Buildings to the value of $3 400 000 are under way, and things are humming.

[Note. — Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by June 15, 1909, for publication in a subsequent number of the Journal.]

BRIDGE DESIGNING.

By Carl Gayler, Member of the Engineers' Club of St. Louis.

[Read before the Club, February 17, 1909.]

In order to make my views, on the subject which I bring before you, clear to you, I have to ask you to go back, in your minds, to former years and to let pass in review some facts and conditions in bridge building which, even if they are familiar enough to some of you, are worth recalling.

About forty years ago, or, to be more accurate, on February 26, 1868, the first stone was laid on the Eads Bridge; in 1872 work was begun on the East River Bridge, and in the fall of 1876 erection of the first cantilever bridge in the United States, Shaler Smith's Kentucky River viaduct, was started. So, in the late sixties and the early seventies, bridge building in this country may be said to have entered on a new era.

Not that this era was needed to put this country into the front rank among bridge-building nations. The writer received his engineering education in a German university, and all that we students were taught about wooden bridges was based exclusively on American examples: The Howe truss, the Brown system, the Burr system, the improved Howe system, etc., arches, combined truss and arch, etc. I recollect well our old professor explaining that the art of building wooden bridges had been developed and exhausted by the American bridge builder.

Likewise the long-paneled, pin-connected metal truss with its admirable features — definiteness of stresses, accuracy of workmanship and ease of erection — was a subject of serious study to the European engineer, and if, with the shop facilities of the present day, with power riveters for shop and field and the advantage of greater rigidity of riveted joints, the pin-connected truss is now losing ground before the riveted truss, it will always be a matter of just pride to this country to have originated the same.

It is not easy for us to realize the state of bridge building in those far-off days.

It was the time of the cast-iron top chord and end — and intermediate post; or, in cases where patented wrought-iron columns — the Keystone, the Phœnix or similar columns — were

used, it was, at least, the time of the cast-iron joint. The eyebar, used sometimes in forms which would appear very strange to us, was being developed, and a number of years passed by before pin-moments and pin bearings were taken account of; even the use of pins, just as they came from the rolls, not turned off, was not unknown. The strain sheet can hardly be said to have been in general use, and such strains as were calculated were worked out on the basis of uniformly distributed loads; even for floor beams and stringers the assumption of concentrated loads was something unknown. It was still a general practice of the bridge builder to continue the counters to the end of the trusses, also to claim that wrought-iron stood an ultimate tensile stress of 60 000 lb. per sq. in.; and, testing machines not being in general use, this claim went unchallenged. It is a noteworthy fact that in the contract for the superstructure of the Eads Bridge, for the first time in the history of American bridge building, elastic limit and modulus of elasticity were prescribed.

Now in these dark times, Captain Jas. B. Eads conceived and carried out the idea of building a steel arch bridge at St. Louis, over the Mississippi River. It is not necessary to tell you that the difficulties which had to be overcome were enormous. The very material to be used for the chords of the arches had actually to be discovered. The expression "infant industry," since so much abused, could in full truth be applied to the condition of manufacturing steel in those days, at least for such large members as the staves, enveloping sleeves and the couplings of the Eads Bridge arches. The Eads Bridge was opened to traffic on July 4, 1874, and has carried its heavy loads, far exceeding any loads dreamed of at the time the bridge was planned, ever since, — now thirty-five years.

In the summer of 1907 the great Quebec Bridge over the St. Lawrence River fell during erection, carrying down to sudden death over 90 men. There is no necessity for enlarging on the facts, — you are familiar with them. Many structures have gone down during erection, some through carelessness, some owing to risks unavoidable during erection, such as sudden rise in a river, masses of ice, etc. The Quebec Bridge disaster belongs in none of these categories; its weakness was inherent in the structure, and could be observed and was so observed in the gradual deformation or buckling of the bottom chord members of the shore arm.

Every disaster, except perhaps an earthquake, teaches its lessons. The lessons which I have drawn from the Quebec dis-

aster may differ somewhat from those reached by other engineers, but I ask your patience to listen to what I think are carefully considered reasons for my conclusions. For further explanation of the latter, I rely to some extent on a comparison of the Eads Bridge and the Quebec Bridge. In spite of the disparity in magnitude and length of spans, the two structures are not unequal in boldness, if the time in which the Eads Bridge was built and the new material which was used are taken into account. And now let us see what chances either of the two works should have had to survive the other, confining our comparisons to the superstructures.

The assumed live loads for the main arches of the Eads Bridge were: 2 000 lb. per lin. ft. of each railroad track and 4 000 lb. per lin. ft. of upper roadway, including sidewalks; total live load therefore equals 8 000 lb., or 2 000 lb. per lin. ft. of each arch.

Both chords of the arches are continuous in the center and are anchored at their ends, thus representing a type of arch bridge not before attempted and requiring theoretical computations likewise not worked out before. The very proportions of the arches, with a versed sine of one tenth, demanded the use of hard steel to avoid excessive temperature stresses.

Let us now sum up and look somewhat closer into the various features of this remarkable structure, which in the light of our experience of to-day would make it easy for any of us to explain, in case it did fail, why it did fail, the only wonder being that it had not failed before.

1. The chords of the arches are built of hard steel, elastic limit 40 000 lb., ultimate strength 100 000 lb. Suitable steel for the parts composing, the chords, i.e., the staves, enveloping shells and the couplings, were obtained after numerous failures, and no such uniformity of the material could under such conditions be obtained as the merchantable structural steel in use to-day.

2. The assumed live loads for the railroad tracks are about one half of present-day practice, considering that no allowance was made for concentrated loads or excess of engine loads.

3. The allowed unit stresses, on the other hand, 30 000 lb. per sq. in. in compression and 20 000 lb. per sq. in. in tension, exceed the unit stresses allowed to-day.

4. No allowance was made in additional square inches for alternating strains in the arches.

5. The computations, admirable as they are, presuppose

a material with a uniform modulus of elasticity; furthermore a uniform sectional area of the chords was assumed with heavier sectional areas for the ends for a distance of one twelfth of the length of the span. As actually built, there are six different sectional areas of the tubes.

6. There was no attempt made to proportion the hard steel pins according to bending moments, nor, what is more serious, to proportion the heads of the wrought-iron diagonal eyebars according to their bearing on the pins.

The floor system, having since been strengthened or renewed, needs not to be gone into.

To sum up, the arch chords are of hard steel of far from uniform quality, the assumed loads are small, the allowed unit stresses great, the computations, to be at all feasible, were based on assumptions which do not coincide with the actual conditions. In proportioning the details, our experience gained during the forty years since the planning of the Eads Bridge was, of course, not available.

In the case of the Quebec Bridge, it is not necessary to enter into the question of loading and unit stresses at all. Like the Tay Bridge, like the Ashtabula Bridge, probably like every bridge that ever failed, it failed through faulty design, not through overloading. It is true that the specifications allowed higher unit stresses than the standard specifications of to-day, but we do not know, nor shall we probably ever know, whether the judgment of Mr. Cooper in this respect was at fault or not. According to the careful investigation of Mr. C. C. Schneider, the members which caused the downfall of the Quebec Bridge were at the time of failure stressed to a pressure of less than 20 000 lb. per sq. in. Now, if our work were liable to succumb under such a stress, the sleep of us poor bridge engineers would be as surely " murdered " as old King Duncan's.

The failure of the Quebec Bridge is due to faulty design; the success of the Eads Bridge is due to its admirable design; and, in trying to explain and illustrate this, I wish also to call your particular attention to the position which the engineer, the man who did design and plan a structure, used to hold and should hold and does not hold to-day.

Fig. 1 and Fig. 2 show the cross-sections of the main compression members of the Eads and the Quebec bridges and they tell their own tale; the tubes of the former the ideal shape to resist compression, the latter probably the most unfortunate shape ever prepared by man for a compression member. A great

deal has been written on the latticing adopted for these chords, and there is no doubt that a double lacing of 3 by 4 by $\frac{3}{8}$ in. angles is more appropriate for a 400 or 500 ft. truss bridge than for an 1 800 ft. cantilever span; but, assuming that the latticing had been designed of sufficient rigidity to hold the four webs in line, what would have prevented the webs themselves, 54 in. high and about 4 in. thick, from bulging?

Now, somewhat to explain the remarkable fact that such a shape could be proposed, could be built in the shop and put in position, unchallenged, let us go back to where we considered the era of bridge building forty years ago. Those master bridge

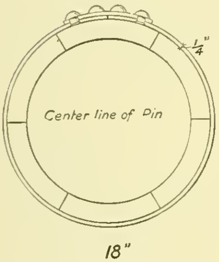

FIG. 1

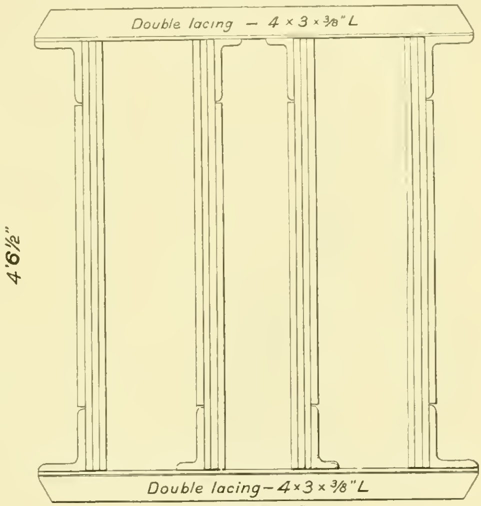

FIG. 2

builders, Eads and Roebling, passed away and new factors began to make themselves felt. Mr. Theodore Cooper, formerly chief inspector for the superstructure of the Eads Bridge, published the first standard specifications for railroad bridges, and it can truly be said that no one man has exerted a like influence on the evolution of the American bridge. His great ability, his utter conscientiousness, his ceaseless study of the requirements of bridge work under changes of material and loading, were rewarded by the fullest confidence, a confidence justified by the success of all bridge work based on his specifications. Few facts are more pathetic than that this man, towards the end of his career, was overtaken by fate and failed in the greatest work with which his name has been connected.

About the time of the publication of Mr. Cooper's first standard specifications, a new class of professional men, the bridge engineers, can be said to have made their appearance, with the building of the Cincinnati Southern Railroad, about 1876. The times of the rule of thumb disappeared and to the trained bridge engineer we owe the present perfection of bridge work in all its details. The importance of detailing with a view of facilitating the work in the shop began also to become an important feature in bridge designing. In short, bridge superstructures began to be manufactured like steam engines or dynamos, the design became more or less routine work, American bridge companies competed successfully in foreign countries with English and German firms; things were running in tolerably worn channels.

It was all so easy. Perhaps too easy. All a man had to do was to specify for his bridge or trestle or viaduct Cooper's A, B or C, as the case might be, check the strain sheets and details submitted by an obliging bridge company and turn the inspection over to some inspection company; it was, as Hamlet says, "as easy as lying."

Now all of this may appear to be expressed too strongly, and it is too strong for 99 cases out of 100. But in the hundredth case, and the hundredth case just includes work of unprecedented character, this routine system fails, and to explain this failure as demonstrated by the Quebec Bridge, let us consider somewhat more fully the standard compression member of American bridges.

After abandoning cast-iron for compression members, the uniformly adopted cross-section was the box or U-shape, one side left open and laced for the connections with the web members. This U-shape is an exceedingly serviceable shape and a good shape. With an increase of square inches in the section, the horizontal member served more and more merely as lacing or tie for the two vertical (web) members. But with still further increase of the sectional areas, and especially on account of the pin moments, this two-webbed section became insufficient and the step to the four-webbed section was easy and natural. The four-webbed section was also a serviceable section, very convenient for the work in the shop, but it was, essentially, not an advantageous section to resist compression. The angles at top and bottom of the webs, necessary for stiffening and for the connection with the lacing or plates which connect the webs, were furthermore found to be in the way of the posts and diagonals and liable to be curtailed in the design. So we see that the

faulty compression members in the shore arm of the Quebec Bridge are not an isolated case in American bridge work. They are the end, the limit reached in a line of evolution, of an objectionable design, adopted without misgivings in former work and also, for example, on the Memphis, Thebes and Blackwell's Island bridges.

And why should there have been misgivings? There were no testing machines available for testing compression members of such sizes and lengths, and American bridge building stood so high in the estimation of the world that no voice was raised against the routine into which we had fallen in the design of compression members.

Now, to resume our comparison of the Eads Bridge and the Quebec Bridge. The Eads Bridge is called by Mr. David A. Molitor "a model of æsthetic design." An unprecedented amount of labor and time, in the St. Louis office, was spent in merely "proportioning" it. The structure would have been just as serviceable if the three arches had been of equal length, if the center arch and the adjoining ends of the side arches had been on a level with the bearings at the abutments, if the grades of the railroad and roadway floors had not been built to the exact lines of parabolas. It is true the beauty of the tubes, with their compactness and simplicity, was partly obtained by striving for the advantage of a protection of the compression members, the six enclosed staves, against atmospheric influence in a manner superior to any other bridge member known except the wires of the Roebling cables inside of their wire wrappings. The wrought-iron skewbacks, Fig. 4, which on their cast-iron bed-plates dis-

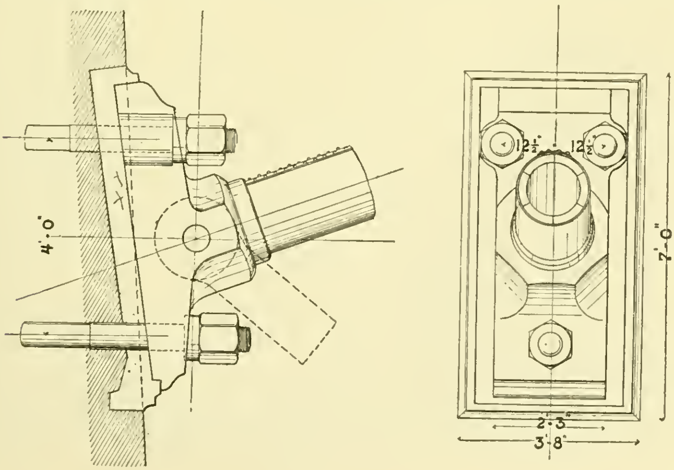

FIG. 4.

tribute the pressure of the tubes over the granite bearings, have always seemed to me to be of a design to be admired beyond any bridge pedestal ever designed. No doubt they were expensive and anything but "convenient for the shop"; in fact, there could be found, in those days, only one shop in the country, way up in New Hampshire, with a steam hammer powerful enough to forge them. But is not, in permanent structures built in our large cities, beauty of design justified even at somewhat increased cost? There is not an ornament added to the Eads Bridge, its beauty is all in its proportions.

And here I beg leave to put on record the fact that this proportioning, this designing of our bridge, was the exclusive work of Jas. B. Eads. The credit for this was never before given to him, but it is due to him as surely as the exclusive credit for the computations is due to Mr. Charles Pfeifer, and the exclusive credit for the bold manner of erection to Col. Henry Flad. The opinion which I herewith put on record as the last man living who followed and took part in the work of designing the Eads Bridge in the office, if in a subordinate position, should be of some weight.

The plans of the Quebec Bridge were prepared by the engineers of the Phœnix Bridge Company, based on the specifications adopted by the Quebec Bridge Company and afterwards modified by the consulting engineer, Mr. Cooper. It is the simple shape of a cantilever known to us almost to satiety. Somewhat striking in the design is the evident reduction of masonry to a minimum. If the bridge had ever been completed, its most striking feature, however, would have been its two main towers (Fig. 3), each consisting of two vertical legs, 5 ft. by 10 ft. each, 67 ft. between centers and 315 ft. high, with lateral bracing between. There is no parallel to such a tower; the legs have no batter; they are pin bearing at both ends; nothing whatever has been done to give the towers the appearance of stability or massiveness which might have been expected from their height and the duties they would have had to perform. I leave you to judge of such a design yourself, and will only add that it is a great pity the Quebec Bridge broke down as soon as it did. It might have become a very interesting object lesson.

A cantilever bridge has some peculiar features which distinguish it from the ordinary truss: The loads imposed on the center span produce strains which have to travel great lengths till they reach the anchorage, which fact accounts for the great deflections inherent to this system. The bottom chords — and this

is more important even, especially where built in the form of an arch, as in the Quebec Bridge — have to be held rigid by the web system. Now, consider that the bottom chord of the shore arm of the Quebec Bridge, the member whose failure caused the downfall of the structure, with its calculated pressure of ten thousand tons, had thus to be held rigid by the top chord and by means of a web system over 100 ft. high at one end and over 300 ft. high at the other end. The great Forth Bridge has been called a "monstrosity," and not unjustly; yet there is that in its design which takes into account the great duties it has to perform and which might well have served as a lesson to the engineers whose names are connected with the Quebec Bridge. Consider also that, for a reason which will be touched upon further on, "the actual units stresses in some of these web members are in excess as much as 21 per cent., — in one case 50 per cent. — of the limits of the specifications" (C. C. Schneider), the specifications themselves, as above remarked, allowing unit stresses in excess of present-day practice.

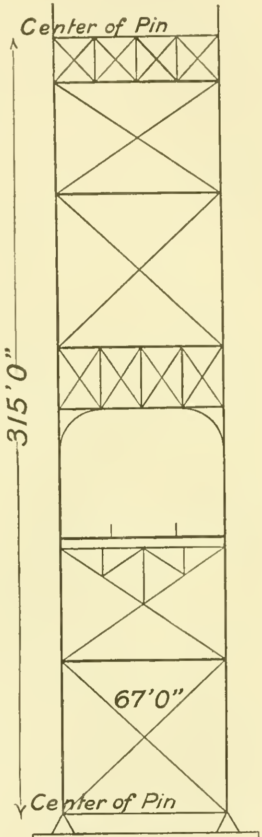

FIG. 3

Do not misunderstand me: This is not said in a spirit of fault finding, but it is our duty to try to profit from such lessons. What I have brought before you so far was brought forward principally to impress on you the fact that bridge building cannot become a matter of routine without great danger. There is no doubt that the Quebec Bridge superstructure consisted of excellent material; no fault can be found with the inspection; the structure is simple and the stresses could be accurately ascertained. The details were admirably adapted to the work in the shop — what more desirable shape for shop work could be designed than the four-webbed compression members, each web consisting of 4 plates, $4\frac{1}{2}$ ft. wide, with angles at the ends and connected by lacing? Of real "designing" there was practically none; the

exigencies of the shop seem to have overshadowed everything. In examining the plans of the Quebec Bridge, we get the impression that the one paramount idea, from the conception of the general plans down to the minutest detail, over-riding every principle of true designing, not to speak of any considerations of æsthetic effect, was to obtain a superstructure which could be built with the greatest ease, the greatest dispatch and at a minimum cost by the shops of the Phœnix Bridge Company. It is not too much to say that the position of the consulting engineer approached close to that of an examining and auditing chief clerk; and the bridge company's engineer, through the demands of the shop for additional shop drawings, was hurried so that not even sufficient time was given him to carefully plan and carefully estimate and check the weights of the different members of the structure. This is admitted in Mr. Cooper's testimony and conclusively proven by the one fact that, *after the bottom chords of the west shore cantilevers were completed in the shop*, the weight of the 1 800 ft. center span was found to exceed the formerly estimated weight by, according to one testimony, as much as 25 per cent. It seems next to incredible that this greatest bridge undertaking of our day should have been thus mismanaged, and that the engineers connected with it acquiesced and lent their approval to it.

To speak of the compensation which the consulting engineer received for the work thrust on him, and for his tremendous responsibility, would be too painful.

The position of the bridge engineer, both of the company's engineer and of the consulting engineer, had with the Quebec Bridge reached its lowest level. Not that this case can be considered as the universal practice of to-day, but the magnitude of the work could not but help to bring this question glaringly into the light.

There are pathetic features about the downfall of the Quebec Bridge, and the world-wide reputation of American bridge building has received a setback which it will take many years to overcome; but if, through this great disaster, the importance of the work of the designing engineer is raised in public opinion, even this dark cloud is not without its silver lining.

[NOTE. — Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by June 15, 1909, for publication in a subsequent number of the JOURNAL.]

ANNUAL ADDRESS.

By Archer E. Wheeler, President of the Montana Society of Engineers.

[Read before the Society at Great Falls, Mont., January 9, 1909.]

Members of the Society and Gentlemen:

It devolves upon me, as retiring President of the Society, and in accordance with its constitution, to address you at this, your annual meeting, upon the general condition of the Society and the progress of engineering construction in Montana during the past year.

The state of Montana has, during this year just completed, been particularly fortunate in the matter of construction work carried on. While in most parts of the country such work has been very much curtailed and, in fact, in many cases stopped entirely, there has been in this state a large amount of work prosecuted, and much projected and started. The railroads have continued construction work which they had under way, the large mining companies have continued much of their new work and several water-power developments have been carried forward or planned and started, while the Reclamation Service of the government has carried on its work without unusual interruptions. The upbuilding of the state, as evidenced by the building of homes, has gone on in a manner quite equal to similar building in years which are considered as much better years in general business conditions. Montana can well congratulate herself on having gone through the year with no more serious effects of the disturbed business conditions than have been made evident.

The Secretary's report will give in detail the condition of the Society. It is, in general, as he expresses it, "normal," although I am glad to state that it is somewhat better than this financially. The increase in membership will, I think, with the voting in of recent applicants for membership, be quite gratifying.

It was agreed at the last annual meeting to attempt to hold a midsummer meeting in 1908. It has always been very difficult for members to attend such a meeting, as it is at the season of the year when an engineer, in the active practice of his profession, is most apt to be busy. The failure of any meeting to materialize this year at the time agreed upon, June, was not,

however, directly traceable to this cause, but to the actual impossibility of traveling during the month, owing to the unprecendented floods and consequent washouts on the different railroads. The failure of this proposed meeting should not be considered as reason for the abandonment of any attempt in the future to hold a midsummer meeting. Such a meeting, for those who could attend, would be of great value, as work could then be seen during actual prosecution instead of, as at a winter meeting, after it is nearly or wholly completed.

A large part of the work which has been carried on during the past year can be brought under one of the five following heads:

Work of the United States Reclamation Service.

Work by the railroad companies.

Water-power development.

Operations, improvements and extensions at the mines.

Improvements and enlargements at the smelters, and I will present what review I can in the above order.

Work of the United States Reclamation Service.

The Reclamation Service is carrying on in this state four primary projects:

The Huntley project, the Lower Yellowstone project, the Milk River project and the Sun River project. To these might be added the St. Mary's project, which, while not strictly so classified, may almost be considered as a separate project.

The Service also has charge of all irrigation work on the Indian reservations and has already completed about eight per cent. of the proposed work on the Blackfeet Reservation and is making surveys for a project on the Flathead Reservation. At the risk of including work which was completed in years other than 1908, I will outline briefly these projects and the work done on them.

The Huntley project, which takes its name from the town of Huntley, at the junction of the Burlington and Northern Pacific Railroads, is in Yellowstone County, Townships 2 and 3 North, Ranges 27 to 31 East, Latitude 46 degrees North, Longitude 108 degrees West from Greenwich, and takes its water from the Yellowstone River. The watershed is 11 180 square miles, with an average rainfall of from 10 in. to 15 in. per year. The average elevation is 3 000 ft. above sea level and the range of temperature is from minus 35 degrees to 100 degrees fahr.

The total land included in this project is 36 214 acres, of which 29 144 acres are irrigable. The land is divided as follows:

Public land, 32 614 acres, divided into 594 farms, containing 26 056 acres of irrigable land, or an average of 54.9 acres per farm, each containing an average of 43.9 acres of irrigable land.

Preference right lands, 871 acres, of which 755 acres are irrigable, and Indian allotments, 2 729 acres, of which 2 333 acres are irrigable. The duty of the water is to be 2½ acre-ft. per acre per year, or a total for the iriigable land of 72 860 acre-ft. per year.

The development consists of a direct intake from the Yellowstone River through reinforced concrete head works, provided with two steel gates 5 ft. by 7 ft.; thirty miles of canals and two hundred miles of laterals. The distributing system has required the construction of three tunnels, designated as Nos. 1, 2 and 3, which are, respectively, 700 ft., 1 550 ft. and 400 ft. long and are all 9.2 ft. wide and 9 ft. high. At one point in the system 600 h.p. has been developed with vertical turbines. These are direct connected to centrifugal pumps, with a capacity of 56 cu. ft. per second. The water so pumped is used to irrigate about three thousand acres on the Ballantine Bench. The townsites on this project are Huntley, Osborn, Worden, Ballantine, Cartersville, Anita, Pompey's Pillar and Bull Mountain. All the work on this project has been completed.

The Lower Yellowstone project is in Dawson County, Mont., and McKenzie County, No. Dak., Townships 18 to 26 North, Ranges 56 to 60 East in Montana, and Townships 150 to 152 North, Range 104 West in North Dakota; Latitude 47 degrees North, Longitude 104 degrees West from Greenwich. The elevation is from 1 865 ft. to 1 980 ft. above sea level. The project takes its water from the Yellowstone River from a watershed of 66 000 sq. miles. The average rainfall is from 16 in. to 20 in. per year. The temperature varies from minus 49 degrees to 107 degrees fahr. The irrigable area is 66 500 acres, being a strip from ½ mile to 5 miles wide, beginning at a point about 18 miles below Glendive and extending to where the Yellowstone River flows into the Missouri.

The duty of the water is one second-foot to one hundred acres, the annual duty depending, of course, upon the length of time during which water is allowed to flow over the land. The diversion dam is timber covered, rock filled, 700 ft. long, 50 ft. wide and 12 ft. above stream bed and is built on a pile foundation. The distributing system consists of a main canal 67 miles long

and 207 miles of laterals. There is one power development of 290 gross h. p. obtained by using 86 second-ft. through 29½ ft. fall. This power is developed by turbine driving a direct-connected centrifugal pump, which is used to lift 34 second-ft. of water through 31½ ft. This project is 89 per cent. complete.

I have been unable to obtain information as to the Milk River project and must, therefore, omit any description.

The St. Mary's project is in Teton County, Latitude 49 degrees North, Longitude 113 degrees West from Greenwich. The watershed from which the water is taken is 452 sq. miles, with an average rainfall of 60 in. per year and an average run-off of 40 in. per year.

The development consists of a storage reservoir with a capacity of 150 000 acre-feet and a canal 25 miles long. The dam forming the reservoir is an earth embankment 42 ft. high and 2 070 ft. long, and in the distributing system is a tunnel 12 000 ft. long with a capacity of 850 cu. ft. per second. The irrigable land on this project amounts to 100 000 acres, of which 60 000 acres are in the Blackfeet Reservation and 40 000 acres are to the east of this.

The Sun River project is in Cascade, Teton, Chouteau and Lewis and Clark counties. It is planned here to use the waters of the Sun River to reclaim about 276 000 acres in the watersheds of the Sun and Teton rivers.

The ownership of this land is approximately as follows:

United States Government	180 000 acres
Montana State Government	22 000 acres
Private Owners	74 000 acres

The general plan is the diversion of some of the smaller streams into the larger ones and the conservation of the flood waters in large reservoirs for distributing during the irrigating season. The watershed of the Sun River is estimated to be 850 sq. miles and that of the Teton 290 sq. miles, with an average annual rainfall of 12 in. or a total of 729 600 acre-ft. The north fork of Sun River, from which the principal supply will be obtained, is estimated to have a minimum run-off of 400 000 acre-ft. and a maximum of 1 000 000 acre-ft. As it is expected that the reclaimed land will require about 1½ acre-ft. per acre per year, it will be seen that the supply is ample.

To conserve this water, four storage reservoirs are planned:

The Warm Springs Reservoir, in the mountains.

The Willow Creek Reservoir, near Augusta.

The Pishkun Reservoir, north of Sun River, and

The Benton Lake Reservoir, about eight miles north of Great Falls.

The Warm Springs Reservoir has a superficial area of 1 976 acres and a capacity of 157 000 acre-ft. The dam is 762 ft. long on the crest, 190 ft. high above the river bed and 213 ft. high above foundations and is built of loose rock with hydraulic fill backing. The outlet from this reservoir is by a tunnel 1 000 ft. long.

The Willow Creek Reservoir has an area of 2 285 acres and a capacity of 84 000 acre-ft. The dam will be 1 045 ft. long on the crest, 110 ft. high above the river bed and 124 ft. high above the foundation. It will be hydraulic fill. The outlet will be by tunnel 584 ft. long. This tunnel has already been constructed.

The Pishkun Reservoir has an area of 1 542 acres and a capacity of 46 000 acre-ft. The dam is 20 ft. high above the river. The outlet is by tunnel 430 ft. long.

The Benton Lake Reservoir has an area of 9 130 acres and a capacity of 140 000 acre-ft. The dam is 120 ft. long on the crest and 35 ft. high, earth fill.

Two diversion dams are required — one in Sun River Cañon 72 ft. high and 150 ft. long on the crest, and one on Deep Creek 12 ft. high and 100 ft. long on the crest, both of reinforced concrete. There will be three canals: the Main Canal, divided into the South Side, 8 miles long, and the North Supply and High Line, 52.1 miles long; the Teton Slope Canal, 83.1 miles long, and the Fort Shaw Canal, 12 miles long. The latter is already constructed. On these main canals there are four tunnels: No. 1, 5 000 ft. long; No. 2, 1 400 ft. long; No. 4, 2 200 ft. long and No. 5, 2 000 ft. long.

Of the Laterals, the Fort Shaw Lateral, 39.5 miles long, is the only one constructed. The North Side Lateral is not yet surveyed, but it is probable that this North Side distributing system will require over 2 000 miles of canals and ditches.

The contour of the country has necessitated pressure pipes or inverted siphons in the distributing system. At Simms' Creek a pressure pipe 1 565 ft. long and 5 ft. 3½ in. inside diameter of reinforced concrete has been constructed. At Priest Butte Sag a pipe 4 400 ft. long and 10 ft. inside diameter will be required, and at the Montana and Great Northern Railway crossing one 3 400 ft. long and 6 ft. in diameter will be required. Preliminary work was begun on this project in July, 1904. The project is divided into three units: The Fort Shaw Unit and two other Units not yet named.

The Fort Shaw Unit. — Actual construction work was begun on the Fort Shaw Unit in May, 1907, and was continued through the summer of 1908, and there are now 16 000 acres under ditch, for which water is ready. Water was first turned into the canals July 21, 1908, and turned off for the winter on October 24, 1908. The size of the farms as they are laid out varies from 40 acres to 160 acres. These were first opened to settlement on May 7, 1908, and up to this time 12 per cent. of the total number of farms and of the irrigable land has been filed upon. The new settlers are building their homes and beginning the cultivation of their lands and it is expected that this unit will be practically settled in its entirety during the coming year and work will be prosecuted upon further units of the project.

Work by the Railroads.

The railroad work in the state has consisted of the extension of the Chicago, Milwaukee and St. Paul Railway, now named the Chicago, Milwaukee & Puget Sound Railway, extensive line changes by the Northern Pacific, the construction of some new lines by the Northern Pacific, the construction of the Billings and Northern and line changes by the Great Northern and Montana and Great Northern.

The Chicago, Milwaukee & Puget Sound Railway Company.— The surveys for the road were begun on December 25, 1905, and since then the line has been completed as far west as Butte. Freight traffic to that point was started early in the year and passenger traffic has recently been inaugurated. The approximate length of the line from Chicago to Seattle is 2 175 miles, and the length of the line in Montana will be 753 miles, entering on the eastern boundary at Marmouth and leaving on the western boundary at the St. Paul Pass Tunnel. The main range of the Rocky Mountains is crossed through the Pipestone Pass, about fifteen miles east of Butte, and the Bitter Root Mountains are crossed at St. Paul Pass at an elevation of 4 169 ft. above sea level. As a large part of the work on the road during the year has been west of Butte, I will refer more particularly to that part.

The line west of Butte is located along the Deer Lodge, Hellgate, Missoula and St. Regis rivers. It has been constructed with a maximum grade of six tenths of 1 per cent., except the crossing of the Bitter Root Mountains, where a 1.7 per cent. compensated grade is used. The maximum curvature is 3 degrees,

except on the mountain grade, where 10 degree curves are used. It is expected that early in January, 1909, the grading, tunneling, except that portion of the St. Paul Pass Tunnel which is in Idaho, and the bridging will be completed and the track will be laid for 140 miles over this territory. Thirty miles of this track have already been ballasted.

There are six tunnels besides the St. Paul Pass Tunnel, aggregating 4 862 linear ft. The St. Paul Pass Tunnel, through the Bitter Root Mountains from the head of Rainy Creek in Montana to Cliff Creek in Idaho, is 8 751 ft. long from portal to portal. The summit of the grade of the whole line is 3 518 ft. from the east portal of this tunnel and is at an elevation of 4 169 ft. above sea level and 1 020.7 ft. below the surface. The grade in the tunnel is 0.2 per cent. each way from this summit. An interesting feature in the construction of this tunnel is the use of an air-operated shovel of 1¼ yd. capacity. The tunnel is 18 ft. 6 in. by 25 ft. inside the timbers, with a theoretical excavation of 18.5 cu. yd. per linear foot.

Up to December 1, 1908, there had been driven 6 877.5 ft. of tunnel, all timbered complete except 1 302 ft. in the west end.

The record of progress for the six months ending on December 1, 1908, was as follows:

St. Paul Pass Tunnel.

	East End.			West End.			Both Ends.		
1908.	Heading. Feet.	Bench. Feet.	Tunnel. Feet.	Heading. Feet.	Bench. Feet.	Tunnel. Feet.	Heading Feet.	Bench. Feet.	Tunnel. Feet.
June,	203	325	264.0	333	309	321.0	536	634	585.0
July,	249	207	228.0	295	319	307.0	544	526	535.0
August,	318	200	259.0	310	415	362.5	628	615	621.5
September,	306	218	262.0	254	333	293.5	560	551	555.5
October,	320	272	296.0	227	342	284.5	547	614	580.5
November,	340	328	334.0	268	527	397.5	608	855	731.5
Total,	1 736	1 550	1 643.0	1 687	2 245	1 966.0	3 423	3 795	3 609.0
Average per month,	289.3	258.3	273.8	281.2	374.2	327.7	570.5	632.5	601.5

This shows some very good progress, particularly the month of November. The daily progress during this month was as follows:

St. Paul Pass Tunnel.

Daily Progress for November, 1908.

	East.		West.		Total.		
	Heading.	Bench.	Heading.	Bench.	Heading.	Bench.	Tunnel.
1	8	9	7	13	15	22	18.5
2	10	12	0	11	10	23	16.5
3	11	5	15	16	26	21	23.5
4	14	12	12	13	26	25	25.5
5	12	10	11	17	23	27	25.0
6	11	10	6	15	17	25	21.0
7	11	12	11	15	22	27	24.5
8	11	10	11	15	22	25	23.5
9	11	4	12	21	23	25	24.0
10	12	11	12	16	24	27	25.5
11	9	10	7	16	16	26	21.0
12	11	10	12	15	23	25	24.0
13	10	15	12	16	22	31	26.5
14	10	15	13	17	23	32	27.5
15	12	10	17	19	29	29	29.0
16	12	14	14	23	26	37	31.5
17	10	6	11	20	21	26	23.5
18	13	11	19	20	32	31	31.5
19	11	14	14	18	25	32	28.5
20	11	13	16	16	27	29	28.0
21	13	12	10	21	23	33	28.0
22	13	12	12	22	25	34	29.5
23	10	11	6	21	16	32	24.0
24	12	11	8	20	20	31	25.5
25	11	11	0	22	11	33	22.0
26	12	12	0	17	12	29	20.5
27	12	13	0	17	12	30	21.0
28	12	8	0	21	12	29	29.5
29	13	12	0	16	13	28	20.5
30	12	13	0	18	12	31	21.5
	340	328	268	527	608	855	731.5

Note. — No progress was made in West Heading from the 25th to the 30th inclusive; account talc seam very wet, running ground.

It is expected that the tunnel will be entirely completed by May 1, 1909.

Northern Pacific Railway. — The work done by this company has consisted of the double tracking of its line from Garrison to Missoula, including many heavy line changes and grade revisions and the construction of a line from St. Regis to Paradise.

Work was commenced in November, 1906, and was expected to be completed by January 1, 1909. The grading for this work was practically completed on June 1, 1908, but the floods of that month destroyed a great deal of the work and it

has required the balance of this season to repair it. All of the above work for the Chicago, Milwaukee & Puget Sound Railway Company and the Northern Pacific has been done by Winston Bros., and their contracts have included the excavation of something over 20 000 000 cu. yd. of material, exclusive of tunnel excavations and the driving of 29 tunnels varying in length from 100 ft. to 8 750 ft. and aggregating 27 125 ft. Three of the tunnels are double track and the others are single track.

The Billings & Northern and the Great Northern. — The total length of the Billings & Northern line from Armington to Laurel is 194 miles, but in order to make this available for the heavy traffic it is designed to carry, it is necessary to make changes in the Great Northern line from Armington to Great Falls and in the Montana & Great Northern from Great Falls to Shelby.

The grading on the Billings & Northern has required the moving of 10 137 000 cu. yd. of material and the driving of 6 662 linear ft. of tunnel. One hundred and seventy-three miles of the track is laid with 85 lb. rail and 21 miles with 90 lb. rail, Wolhaupter joints and tie plates being used throughout. All track is ballasted with 10 in. of gravel ballast under the ties. The approximate cost of the line will be $11 000 000.

Changes on the Montana & Great Northern mentioned above are being made to reduce grades to a maximum 0.6 per cent. equated grade and to remove the track from water courses and prevent damage by floods. The changes now under way will require the moving of about 520 000 cu. yd. of material. There will still remain some 0.7 per cent. to 1.0 per cent. grades, which will probably be reduced during the coming summer.

The Great Northern Railway suffered very severely from two very serious floods, one in April, 1908, due to the breaking of the Hauser Lake Dam, and, almost before the damage due to this had been repaired, the very heavy flood of June came. There has been a very large amount of reconstruction work done in repairing these damages, but there have been few changes made in the original line.

Water–Power Developments.

The Madison River Power Company. — At the Madison Cañon Station of this company, the No. 1 Generating Station was remodeled and reconstructed and a new stave pipe 12 ft. in diameter and 6 500 ft. long was constructed from the dam

to the generating station, paralleling the 10 ft. stave pipe already in place. This has increased the generating capacity 3 000 h. p. and brought the total capacity at this point up to 15 000 h. p.

Early in September construction was started by the company on a new transmission line from the Madison Cañon to Butte, a distance of 65 miles. The transmission line is to be carried on galvanized steel towers 50 ft. high and spaced from 500 ft. to 1 000 ft. apart. The towers will weigh 2 200 lb. each. The line will be underhung on porcelain disk insulators from steel cross arms, the insulators being designed for a working pressure of 100 000 volts. This is a radical departure from the ordinary construction. It is expected that the line will be completed early in January, 1909.

On the Upper and Lower Madison, the company has made drillings for new dam sites, and the preliminary work on this construction has been done. It is expected that the construction of these dams will be carried out in the near future. The company is also increasing its generating capacity at Livingston, the work now being under way. The increase will be 1 000 h. p.

The Madison River Power Company has acquired the old Parrot property near Whitehall, Mont., and remodeled the canal and installed electrical apparatus, which will be put into commission early in the spring of 1909. It has also extended its high tension transmission line to the town of Whitehall.

Missouri River near Helena. — In April, 1908, the Hauser Lake Dam of the Helena Power Transmission Company went out, practically destroying the dam, but not materially injuring the power house and canal. It was almost immediately decided to rebuild it. In addition to rebuilding this dam, the same company is building what is known as the Wolf Creek dam in the Missouri River near Wolf Creek Station on the Great Northern Railway. Both these dams will be built directly on bed rock, of solid concrete construction, designed so that the weight of the cross section provides against failures by sliding or overturning, and will be of especially massive construction. Between 300 000 and 400 000 barrels of cement will be used in the two dams and the accompanying head works, canals, power houses, etc., and this cement is now being received and hauled to the site of the work by traction engine. When the plants now under construction are completed this company will have installed about 70 000 h. p. of generating capacity with a combined developed head at its three dams of 240 ft. and reservoirs aggregating about 60 miles in length and an average width of about

one mile. The power is being used in Helena and vicinity and in Butte.

Missouri River near Great Falls. — The Missouri River, in a distance of 12 miles below the city of Great Falls, has a fall of 395 ft. This is in five principal falls — Black Eagle Falls, Coulter Falls, Rainbow Falls, Crooked or Horseshoe Falls and the Great Falls.

At only one of these, Black Eagle Falls, is there any power development completed at the present time. It was developed in 1889 to 1891 and now furnishes power for the lights and street railway of the city of Great Falls, for the Royal Mill and for the reduction works of the Boston and Montana Consolidated Copper and Silver Mining Company. The effective head is from 42 to 44 ft., varying with the season, and the power developed amounts to about 12 000 h. p.

In the early summer of 1908, the Great Falls Water Power & Townsite Company, which controlled all the power sites along the river, was taken over by Mr. John D. Ryan and associates and immediately plans were considered for the development of the power. Active work was started in the latter part of August, 1908, at the Rainbow Falls site, and in September at the Great Falls site.

The Rainbow Falls site develops, with one dam, Coulter Falls, which is a small fall, Rainbow Falls, with a fall of 47 ft., and Horseshoe Falls, with a fall of 21 ft. and all the fall in the river between these falls. The dam will be placed above Rainbow Falls. It will be timber crib, rock-filled, with a long apron on the downstream side and concrete-faced along the upper face. The height will be 26 ft. and the length 1 100 ft. The power house will be set in the old bed of the river between an island and the north bank. The water will be carried from the dam to the water wheels through a steel penstock 22 ft. in diameter and about 2 600 ft. long. The available head will be 107 ft. and the developed power about 34 000 h. p. minimum.

The Great Falls site is about seven miles below the Rainbow Falls. Here the natural fall is 77 ft. A dam 26 ft. high and 700 ft. long will be built a short distance above the falls. The power-house site has not yet been determined as the high water in the spring introduced complications. The water will be taken from the dam to the wheels through a penstock 22 ft. in diameter. The available head will be 110 ft. and the developed power about 35 000 h. p. minimum. The electrical installation has not yet been fully decided upon, but will be 3-phase, 60-

cycle, and probably 6 000 volt generators. This will be stepped up for transmission to somewhere between 60 000 and 100 000 volts. The power will be used in Great Falls and vicinity, and in Butte.

Although only a very short time has elapsed since work was actually begun, considerable timber has already been put into the dam at Rainbow Falls and it is expected that the dams at both sites will be practically complete before flood water in the spring of 1909.

Operations and Improvements at the Mines.

In the Helena district practically no new developments have been made during the year. A small amount of construction and reconstruction has been done at the East Helena plant of the American Smelting & Refining Company. This has been done, however, to replace and repair portions of the plant.

The Butte District. — The Boston and Montana mines have operated continuously during the year, except for a partial shut down caused by the June floods, when the ore could not be transported by the railroad company to the reduction works at Great Falls.

The other mines of the Amalgamated Copper Company, which had been shut down in the latter part of 1907, were started on March 1, 1908, and have operated continuously since. The Amalgamated Company hoist between 11 000 and 12 000 tons of ore daily, and employ about 8 500 men. The deepest of the 23 shafts is the High Ore, 2 800 ft. deep, but the lowest stopes are on the 2 400 ft. level of several of the mines, and it may be of interest to note that the ore on these lower levels is of good grade. At the present time the Diamond, Little Mina, Badger State and Leonard No. 2 shafts are being sunk. Development work has been carried forward fully as fast as stoping, and the ore reserves are fully up to what they were a year ago.

Considerable construction work has been carried on during the year. The Pennsylvania shaft has been equipped with a new hoisting engine, head frame and skips. The new Pennsylvania hoist is an Allis-Chalmers first motion hoist of two engines. The cylinders are 32 in. by 72 in. Corliss type, with automatic cut-off gear and governor and also provided with steam reversing gear. The power of the engine is 3 000 h. p., with 140 lb. per sq. in. boiler pressure. The capacity of

the hoist is 34 000 lb., including ropes, or 21 225 lb., exclusive of ropes, from a maximum depth of 3 500 ft. The hoisting drums are two in number, 12 ft. in diameter by 5 ft. 6 in. in face, the cylindrical portion of the drums being of 1½ in. steel plate reinforced with cast steel ribs. They have a capacity of 3 500 ft. of 1½ in. round rope plus two dead rounds. The drums are provided with friction clutches and post brake wheels, all operated by independent steam cylinders and hydraulic oil controlling cylinders. The weight of the engine complete, without ropes, is 527 700 lb. The head frame is of structural steel, 100 ft. high from the base to the center of the sheaves and 112 ft. high from the base to the top of the frame proper. The base is 36 ft. 4 in. wide from center to center of posts and 63 ft. 8 in. long from center to center of posts. The ore is hoisted in self-dumping skips of 5 tons capacity and the men are hoisted in three-deck cages. The skip bins are of steel built as a part of the head frame and are of 150 tons capacity. Pneumatic cylinders are installed for operating the gates in the bin chutes and for operating the skip and cage-changing apparatus. The total weight of the head frame and skip bins is 299 849 lb.

A new compressor plant has been installed at the Leonard shaft. This consists of two 23¼-in. by 40¼-in. by 48-in. cross-compound air cylinders of Ingersoll make and two 22-in. by 37-in. by 48-in. cross-compound air cylinders of Nordberg make, all driven by electric motors, two of 600 h. p. each and two of 550 h. p. each. The capacity of each set of cylinders is 4 000 cu. ft. of air per minute. The Leonard has also been equipped with three electric motor driven pumps; one Aldrich 6-in. by 12-in. quintuplex pump of 400 gal. capacity per min. and two Nordberg 7 in. by 12-in quintuplex pumps of 600 gal. per min. capacity, all under 1 200 ft. head. These pumps have proven very satisfactory and require very much less space than an equal capacity of steam driven pumps and are, in every way, simpler than the steam driven.

Improvements and Enlargements at the Smelters.

Butte Reduction Works. — At this plant a new section of concentrator, the construction of which was begun in 1907, has been completed and put into operation. The tailings from these concentrating operations pile up along each side of Silver Bow Creek and have, for many years, necessitated means of keeping them out of the creek. In 1907 about 1 250 linear ft. of reinforced concrete steel-lined culverts 8 ft. sq., three being

placed side by side, were built, the waters from the creek to be turned through these culverts and the tailings to be piled alongside of or even on top of them. This year the company is building about 800 ft. of culverts of reinforced slag from the smelter operations. As a preliminary to this work tests were made on 1 ft. cubes of the slag, which it was proposed to use for its compressive strength. It was found that the slag would stand from 75 tons to 100 tons pressure per sq. ft. before complete breaking down and, as a result of these tests, 50 tons per sq. ft. was adopted as working compressive strength. The completed structure will consist of three tunnels or culverts side by side, each tunnel 7 ft. 6 in. wide and 11 ft. high to the top of the arch, which is semi-circular. One and one-half tunnels are being completed for the entire length of 800 ft., the water of the creek being carried in the meantime along the ground, which will be occupied by the other half of the completed structure. The floor for the entire length and one half the width is first put in, with reinforcing or anchor bolts projecting up through to anchor the side walls when they are poured. The centers, which are of steel, are then set for one and one-half tunnels in three sections, each 9 ft. long, and end forms set. The molten slag is then poured into these forms and, when completed, the forms are taken down bodily in half-tunnel sections and reset for the next section. Reinforcing rods, which are twisted square bars, are set vertically and horizontally over the arches. At each point where end forms are used, rods are left projecting horizontally about two feet to bind the next section to that already made. When the first one and one-half tunnels are completed for the full length the water will be diverted through the one complete tunnel and the other one and one-half tunnels will be completed. This is quite a new use for molten slag and it seems to promise a successful construction.

The Washoe Smelter at Anaconda. — The construction work carried on here during the year was very small in amount. Extensions were made to both ends of the converter buildings so as to allow an increase in the department. An installation was made for the use of fuel oil in the blacksmith shop and also in starting the McDougall roasting furnaces. This latter does away with the use of wood in starting up or refiring these furnaces.

Boston and Montana Reduction Works. — The construction work at the reduction works of the Boston and Montana Consolidated Copper and Silver Mining Company may be divided into two classes:

First, Rebuilding occasioned by flood damage of June, 1908, and

Second, Strictly new construction.

In June, 1908, there was an unprecedented flood in the Missouri River. Almost the entire drainage area of the river in the western part of Montana and also of the Jefferson, Madison, Gallatin and Beaverhead rivers were simultaneously visited by a very heavy rainstorm in the latter part of May. This came at a time when the earth was well filled with moisture and, consequently, a large part of the water, which fell quickly, found its way into the rivers, and what snow still remained in the mountains was also carried off, the whole resulting in a tremendous volume of water poured into the rivers in a short space of time. All along the rivers much damage was done to the railroads and settlers. At the Boston and Montana plant the water reached a depth of 10.05 ft. flowing over the dam in all except about 80 ft. of its length where the flashboards had been taken out in preparation for the expected floods following the Hauser Lake Dam failure, and in this part the depth over the dam was 14.05 ft. Roughly, the water flowing past Black Eagle Falls was 130 000 cu. ft. per sec. The excess water was controlled until 2.30 P.M., June 6, when suddenly about 90 ft. of the north wall of the headrace gave way, immediately letting a vast volume of water through and around the power houses. No lives were lost. At about 2.30 P.M. of June 8 two head gates broke under the tremendous strain and a still larger volume of water was let into the works. In order to turn the water back into the river, a portion of the south wall of the headrace (next to the river) was blown out. The principal damage was to the headrace, the washing out of a large portion of the yard with its railroad trestles and tracks, the damage to water, steam and air pipes, the destroying of a heavy stone wall between the tailrace and the main channel of the river and the filling of the tailrace with dirt and stone.

After a careful examination of the remaining portions of the headrace walls and a consideration of advantages to be gained by a change in design of the headrace, it was determined to tear out a large part of the old headrace and build a larger one with concrete walls and with different headgate arrangements. An examination showed that the rock on which these walls were to rest, and which was a part of the old river bed, was subject to serious disintegration by frost action. The new walls were calculated for absolute safety against overturning or sliding, the

resultant of forces being made to fall within the middle third, but the further precaution was taken of excavating a trench in the solid rock, about 6 ft. wide and 1½ to 2 ft. deep, which would further prevent any sliding of the wall should the water find its way under the wall and thus exert hydrostatic pressure upward; and as there was on hand a considerable quantity of iron of odd sizes, holes were drilled in the bed rock and these iron rods put in as anchor bolts and left extending into the wall about 6 to 8 ft., which gave additional safety against overturning.

The concrete aggregate was made of 1 part cement, 2.25 parts sand and 4.50 parts freshly broken limestone. This mixture was selected after a series of tests of different mixtures. A plant was built for the handling of the raw materials and the mixing of the concrete. This plant consisted of a central stone bin and a sand bin on each side of this bin, each being kept full of material by an elevator supplied from bins under the railroad track. The cement was stored in a shed alongside and supplied to the mixing machines in batches of five sacks. The machines were two 1¼ yd. Ransome mixers, operated from a motor-driven shaft. The capacity of the plant was about 200 batches of concrete in a shift of eight hours. The total concrete in this work was 7 280 cu. yd.

The headrace, which was previously about 50 ft. wide, was widened at its upper end to 100 ft. so as to take in two gates to the river which had previously been only sluice gates leading from above the dam to the river below the dam. About 50 ft. below the old gates a wall was built across the headrace and seven steel gates built in this wall for controlling the water and letting it into the headrace proper. These gates were of such a size that the water-way through them was about twice what it had been through the old headgates, these old gates being also increased in area as well as taking in the two extra ones mentioned above. This cross wall and the main headrace walls above it were built up to an elevation of 3 294.5 ft. above sea level, which was somewhat higher than the extreme high water of the flood. The seven new gates were of a new design and are raised and lowered by a motor, the shafting being arranged so that any gate can be operated or disconnected. The headrace walls below the gates were also built somewhat higher than they had been previously so as to take advantage of the full head in the river during more months of the year. The top of the wall next to the river is lower than the one away from the river and it is also provided with a spillway so that any sudden rise in

the water level in the headrace, due to sudden closing of a gate or any other cause, will only result in the water flowing over the outer wall into the river.

Dust Chamber, Flues and Chimney. — This system is a complete new flue system for all smelter departments and is being built because the old system is far too small to serve the departments they were formerly designed to serve and because a saving can be made in the recovery and handling of flue dust. Briefly, it consists of gathering flues, one for the blast furnaces and one for the McDougall department, which also receives the converter flue. The reverberatory department will use its old flues for a portion of their distance and these will be led into the new carrying flue some distance below the chimney. The two new gathering flues will be brought together in the smelter building into an uptake and from this a cross-take 39 ft. wide and 21 ft. high will lead across and over the smelter building into the main dust chamber. This dust chamber is 478 ft. 4¼ in. long, 176 ft. 2 in. wide and 21 ft. high inside, rectangular in plan except for 95 ft. at the upper end, where the walls are brought toward each other to lead the gases into the carrying flue to the stack. The construction of all parts of this system, except the chimney, is structural steel, with brick walls and brick roof. The dust chamber is divided lengthwise, approximately, through the center by a brick wall and at both the lower end and the upper end are sets of dampers, by which either half of the flue can be shut off and the gases sent through the other half while any examination or repair is being made. The entire floor both of the dust chamber and the cross-take consists of a series of steel hoppers from which all collected dust can be drawn: that from the dust chamber into cars which run underneath and that in the cross-take into a hopper crane which serves the entire floor. The entire dust chamber, except for a short distance at the lower end and also at the upper end, will be filled with small wires hung vertically from the roof and spaced 2¼ in. center to center. As the results of many experiments on which this whole system was planned, it is expected that these wires will cause practically all the dust which may enter the dust chamber to settle out. Shaking arrangements are provided for cleaning the wires of adhering dust should it be necessary. Both the roof and floor are provided with expansion joints at frequent intervals to allow both longitudinal and crosswise expansion.

The carrying flue leads from the dust chamber to the chimney and is 48 ft. 2 in. wide inside and 1 238.85 ft. long in horizontal

projection from the upper end of the dust chamber to the center of the chimney. Beginning at the upper end of the dust chamber this flue is horizontal for 140.65 ft., then for 144.45 ft. the grade is 30 per cent., then for 637.4 ft. it is 8¾ per cent., then for 152.5 ft. it is 30 per cent., then for 65 ft. it is 15 per cent. and for the balance of the distance, except for short distances of level flue, the grade is 3 per cent. This flue has no wires and no hoppers and is not designed as a settling chamber, but only as a carrying flue. At the upper end this flue branches into two parts, each leading into a flue opening in the chimney, these openings being 90 degrees apart.

The chimney, which is both the largest and highest in the world, is 506 ft. high above its foundation and 50 ft. inside diameter at the top. It rests on a concrete foundation, annular in shape, octagonal on the outside and circular on the inside. This foundation at the top is 81 ft. across the flat on the outside and 64 ft. inside diameter, while at the bottom it is 103 ft. across the flat on the outside and 47 ft. inside diameter. It is 22 ft. 6 in. high and contains 4 300 cu. yd. of concrete. The elevation of the top of the foundation is 3 548 ft. The concrete is a 1 : 2.3 : 4.5 mixture of cement, tailing sand from the concentrator and broken slag from the smelter. The chimney is circular in cross section, except the exterior of the base, which is octagonal. This octagonal base is 78 ft. 6 in. across the flat at the bottom and 74 ft. 9⅞ in. at the top and 46 ft. high, the taper being 8 per cent. In this base are four flue openings each 15 ft. wide and 36 ft. high. The brickwork across the top of these openings is carried on I-beams which are carried on steel bearing plates at each end and are protected from the acid fumes by special brick fitted over the flanges. Only two of these openings will be used at the present time, the other two being bricked up until such time as they may be required for additional flues, the chimney being designed so as to be capable of handling at least twice as much gas as it will at first be required to handle.

The main barrel of the chimney is 73 ft. 11⅝ in. outside diameter at the top of the octagonal base, the main wall, exclusive of the acid-proof lining, being 54 in. thick at this point, while it is 66 in. at the thinnest part of the base, that is, at the center of the octagonal faces. There are four tapers on the outside of the chimney: for 46 ft. from the base 8 per cent., for the next 180 ft. 7 per cent., for the next 100 ft. 4 per cent. and for the last 180 ft. 2 per cent. The main walls at the top of the chimney are 18⅛ in. thick, which, with the lining and air spaces, make an

outside diameter of 53 ft. 9¼ in. The chimney is lined throughout in sections varying from 10 ft. to 25 ft. with a 4-in. acid-proof brick lining, set in acid-proof cement, each section being carried on a corbel built out from the main shell. This lining is set entirely free from the main shell and with an air space of about two inches. The top of each section of lining and the bottom of the corbel next above it are of special shape to provide a drip for any condensed moisture and prevent it running back of the lining. The further precaution is taken to prevent dust from entering the air space behind the lining by filling the space for a distance down from the top with slag wool made on the plant. This wool is prevented from dropping down in the space by projecting courses of brick, one projecting inward from the main shell and one projecting outward from the lining. These courses are not opposite each other, but one is higher than the other to prevent interference in case of expansion of the lining.

The top of the chimney is protected by a terra cotta cap laid in acid-proof cement, and the exterior joints in the brickwork for the top 50 ft. are pointed with the same material. The lightning protection consists of 16 points set 5 ft. above the top of the chimney and connected to a common conductor circling the chimney near the top. From this encircling cable two cables diametrically opposite each other are carried to the ground and grounded in copper plates deeply buried. An exterior ladder of round iron rungs built into the brickwork is provided, and protective loops of round iron are built in at every other rung of the ladder, so that a man when using the ladder is constantly inside these protective loops.

The completed structure contains about 17 000 tons of brickwork. To provide brick with which to build this chimney, a brick plant was erected on the company's land near the site of the chimney and material from near the brickyard used for making the brick. The plant consists of necessary grinding pans, etc., an auger machine of something over 100 tons capacity in 8 hr., a steam drier, an air drier and eight circular beehive kilns, independently fired. Altogether the plant has a capacity of 100 tons per day and it will undoubtedly be possible to make many clay products, such as common brick, perforated brick, paving brick, fire brick, vitrified tile, etc., if desired. It was also necessary to build a railroad to the brick plant and from the brick plant to the chimney site to handle the finished material. I wish in closing to acknowledge my indebtedness to the following for information and data used in the preparation of this paper:

Mr. S. S. Robbins, project engineer, United States Reclamation Service; Mr. W. H. Penfield, engineer of construction, and Mr. W. E. Dauchey, division engineer, Chicago, Milwaukee & St. Paul Railway; Mr. J. W. Ellison, of Winston Bros.; Mr. H. F. Hamilton, resident engineer, Great Northern Railway; Mr. Max Hebgen, general superintendent, Butte Electric and Power Company; Mr. M. H. Gerry, Jr., general manager, Helena Power Transmission Company; Mr. Frank Scotten, superintendent, Great Falls Water Power & Townsite Company; Mr. F. M. Smith, manager, East Helena plant of American Smelting & Refining Company; Mr. B. H. Dunshee, assistant superintendent, Amalgamated Mines; Mr. E. P. Mathewson, manager Washoe Smelter, and Mr. A. H. Wethey, general manager for Senator Wm. A. Clark.

[NOTE. — Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by June 15, 1909, for publication in a subsequent number of the JOURNAL.]

ANNUAL ADDRESS.

By C. W. Wood, President of the Lousiana Engineering Society.

[Delivered before the Society, January 9, 1909.]

According to Section I of Article 4 of our Constitution, the retiring president is required to deliver an address at the annual meeting, and consequently I had prepared an extensive paper covering the work of the past year, but on looking over the reports of the Secretary, Treasurer and the various committees, I find there is very little left for me to say, except possibly to comment upon the facts as set forth in these reports.

Many of the members, and I am one of them, firmly believe the past year has been a strenuous one. We have made many important changes, many that are very advantageous and satisfactory, and others that may not have proven entirely so, but, taken as a whole, we have advanced, gained ground, and that was the aim of the administration.

Among the changes made during the year, the first most important one was the move back from Tulane University to the business center of the city. The results of this move have been thoroughly discussed at various times, but I think they show for themselves and meet with the approval of a large majority of the active members. Our library is large and well arranged and convenient during business hours to fully nine-tenths of the members. We have a neatly and comfortably furnished room for meetings of the Board of Direction and various committees, and the Secretary certainly should be well satisfied with the quarters and facilities furnished him. The only drawback to the present arrangements is that our assembly room, while attractive in many ways, is not large enough to accommodate a full meeting of the members.

However, I trust the day is not far off when the Society will be strong enough to control its own meeting room, well furnished and equipped in every modern detail. I would also suggest the value of more social events during the year. Frequent social intercourse would add greatly in carrying out the original intents of the Society.

The report of the Secretary covers the several amendments

to the Constitution and By-Laws adopted during the past year, and I am confident all of them are steps in the right direction. At our December meeting, and to-night, we have had the first opportunity to test the working of the amended By-Laws as to the nomination and election of officers and, judging from the gentlemen just installed in office, there is no question but that it has worked excellently.

The action of the Society in endorsing and assisting in the passing of Act 308 by the last Legislature, relative to the regulation of the practice of civil engineering and surveying in this state, and the part taken by the Society in organizing the Board of Examiners, etc., need no comment at this time. The provisions of the law have been rather severely criticised by the leading engineering journals and also by a few of the local members of the profession, but I feel confident future results will justify the law. We all realize that there are several weak points that should be amended at the earliest opportunity, but this act is an entering wedge and we may be assured that the law, judicially handled, will eventually result in great good and is a move towards the improvement of the profession.

The technical exercises during the past year, as reported by the Secretary, have been interesting and well diversified, and while our model city or future New Orleans plans, which were projected one year ago to-night, may seem to have lagged during the past few months, I think the able and comprehensive report of Mr. Reed sets forth excellently the amount of work so far accomplished, and further suggests the broad and almost incalculable benefits that may be derived, not only by the members of the Society, but also our home city, by continuing this work along the lines laid out.

As you will also note by the Secretary's report, we have held twelve full meetings, to say nothing of many special committee meetings, all well attended. This is, to say the least, extraordinary, the usual number of meetings being, heretofore, not more than nine, owing to adjournment for the summer months. One condition that probably operated in our favor in this matter was that of the financial depression during a great part of the year, which no doubt gave many of us the time to devote to the affairs of the Society that under other conditions might not have been possible. The work of the engineer, and I refer more particularly to the civilian engineer, is so dependent upon the general prosperity of the country that any fluctuations in that condition affect the engineer first and far more than the fol-

lowers of any other profession. Our work is creative and forward, and consequently any stagnation or retardation in the projecting or building of public or private improvements must necessarily affect him first, and I may say that the demand for his services is very largely a criterion of the general financial condition of the country.

Briefly referring to the physical condition of the Society, I would call your attention to that part of the Secretary's report which shows that one year ago our membership numbered 106; to-night it numbers 135, or a net gain of 29, allowing for resignations, etc., and two deaths. This increase is certainly gratifying and encouraging, as every desirable new member adds a unit to our strength, but I may be pardoned for suggesting that numerical strength alone can do little without the coöperation and lively interest in the affairs of the Society of each and every individual member. As stated before, the attendance at regular and committee meetings has been satisfactory, but there is nothing so good that could not be better, and it is my earnest hope that the coming year will show even better results.

You have heard read the reports of the other officers and committees, and it is not necessary for me to refer to any except that of the Treasurer. The retiring administration is not turning over to the incoming administration any large balance; in fact, it was never our ambition to do so. We thought we were just as competent to spend the money as they will be, and, considering the extraordinary expenses incurred during the past year, the new administration should be thankful for any balance at all.

In conclusion, I wish to thank you gentlemen one and all, not only for the honor conferred upon me by selecting me to preside over this body during the past year, but also for the many courtesies and hearty support extended. I assure you that I shall continue to use my best efforts for the welfare of the Society in the future as I have in the past, and further that it is a feeling of relief and satisfaction to be able to turn over the administration to such able gentlemen as my successor, Mr. John T. Eastwood and his associated officers.

[NOTE. — Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by June 15, 1909, for publication in a subsequent number of the JOURNAL.]

SINKING PUMPS.

By Frank S. Mitchell, Member Montana Society of Engineers.

[Read before the Society, February 13, 1909.]

In presenting for your consideration this evening something new in the way of a sinking pump, I am well aware that I am addressing some of our foremost engineers, men possessing the highest grade of talent and practical knowledge in everything pertaining to the operation of mining in all its branches. The vast necessity of our mining operations demands men of this caliber to successfully handle our mines.

The advance in the line of pumping appliances has hardly kept pace with the progress in other lines of mining machinery. It is indeed a far cry from Archimedes' wheel and the China pump to the modern electrically-driven high-speed pumping-engines of to-day. Yet in the past twenty-five years there has been little change in the design of our mine sinking pumps.

Your practical experience in mining proves to you that the sinking pump has the severest duties to perform under the most unfavorable conditions of all the pumps used in the working of a mine. In twenty-five years of experience in handling and running mining machinery, the writer has learned that the simplicity of any machine is usually the key to its successful operation.

To the layman the running of steam pumps is apparently simple, but the practical engineer knows by experience that really it is not. Here we have three machines in one,—a steam engine, an air pump and a machine for pumping water,—the steam end of the pump representing the steam engine, the water end performing the duties of an air pump in creating a vacuum to form a suction, and the mechanical arrangement of the piston or plunger and valves making the machine for pumping water.

In designing this pump it has been my aim to produce a machine which shall have the fewest parts; to protect it as far as possible from breakage caused by shots or falling rocks; to reduce its weight to the minimum; to reduce the number of valves, seats and springs; to make the operation of the plunger such as to give a continuous flow of water in one direction and

in nearly a straight line through the pump. Referring to Fig. 1 and 2, showing the water end, you will note that all this has been accomplished by the use of a differential plunger.

Our water end is made in two main castings. The upper we will call the discharge chamber and the lower the suction chamber. The joint is made in the center and consists of a recess ring, which locks to two parts in a central position and makes an absolutely tight joint.

We are building our pump ends of cast iron and bronze, and when made of semi-steel they are good for working heads up to 500 ft.

The plunger area on the suction end is 90 per cent. of the suction area, so that the pump will pick up its water without priming. The plunger area is the same as the valve area, so that the pump may be run at any speed, the water traveling in through the valves at the same speed that it does in the column pipe. The plungers are outside packed, so that any air or water leak may be seen at a glance. The total pressure due to water head is always on the discharge plunger as long as there is water in the column pipe, so that the pump will always have a resistance to overcome, thereby preventing hydraulic strains or shocks which occur in other types of pumps.

The valve seat, spring and stem can be quickly replaced if need be by removing the hand-hole plate, and any intelligent miner can do this without calling for the services of a skilled mechanic. The hand-hole plates are hinged to the main castings on the water end and are bolted to the pump with swing bolts. The plunger gland bolts are made in the same way, so that the nuts need not be entirely removed in order to replace a valve or spring or to repack the plungers. The hand-hole plates have a recess cast in face side that is bolted to the pump. This recess is filled with ½-in. fibrous pump packing, driven in tight and allowed to project about one eighth of an inch. This, when faced with graphite and oil, makes a joint which is always good.

Our sinking pump may be bolted to one of the posts in the station set and, with the electric drive, makes a good station pump, where the mine is not making over 200 gal. of water per minute.

The need of something better than either the Cameron or the Knowles sinking pump, which have many points of excellence and are generally accepted as the best types of their class, suggested itself to me after many complaints from customers criticising the Knowles on account of the loss of time, trouble and annoyance in breaking the joints and removing the

entire half of the water end (usually in the sump), to repack the bucket or replace a valve, a seat, a spring or a stem; and, in case of a Cameron, criticising its great weight and the pump losing its water on account of its air pocket; the lower end also forming a pocket for the choking up of the pump with sand and other débris.

It is an admitted fact that there is not in the market to-day a practical and dependable electric sinking pump. There are three conditions which confront the intended purchaser of the electric sinkers which are now on the market:

First, *excessive cost.* Second, *extreme weight.* Third, *occupying entirely too much space in the shaft.*

All these conditions I think I have avoided.

I wish to call your attention to the fact that I am showing you a pump which can be operated by air or steam, and can be operated by electricity by removing the steam cylinder and steam piston and bolting in its place an electric drive, which is illustrated by Fig. 3 and described as follows:

The electric motor is fastened to the upper base plate, and drives on each end of its armature or rotor shaft a right and left hand worm. These worms in turn drive worm gears, which are keyed to shafts which drive two cranks. The crank and worm gear shafts run in solid boxes, which are bronze bushed with oil rings to lubricate the journals. The crank pins are placed opposite each other and the two rods connect the pins with the yoke which is fitted to the piston rod. The angularity of the connecting rods acting against each other acts as a parallel motion for the piston rod and plungers and does away with the cross head and guides which would otherwise have to be used. The worms running in an oil case with the self-oiling boxes on the motor, with grease cups on the crank pins, make a practically self-lubricating machine.

A comparative statement of the weight of the different makes of sinking pumps of the same capacity follows:

No. 7 Cameron	2 300 lb.
10 by 7 by 5 by 10 Knowles	1 200 lb.
Our differential plunger	1 150 lb.

These pumps are all rated at 100 gal. per minute and the same ratio of weights obtains for all sizes.

In conclusion, I will say our steam-driven sinking pumps have been in successful operation for over a year and have more than lived up to our expectations, and we shall soon have them

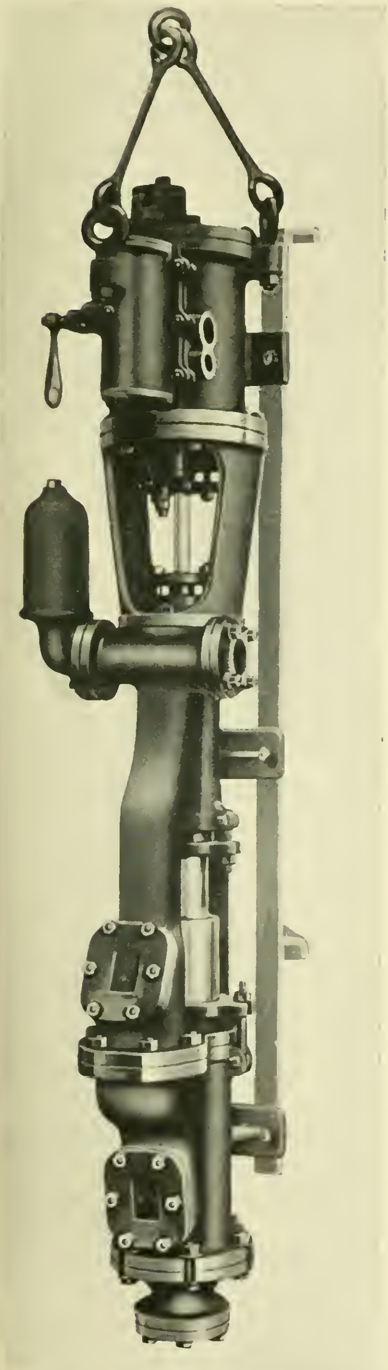

Fig. 1.

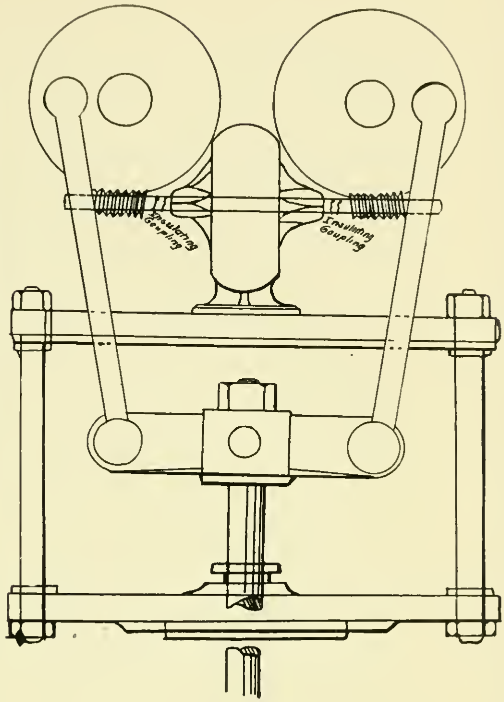

Fig. 3.

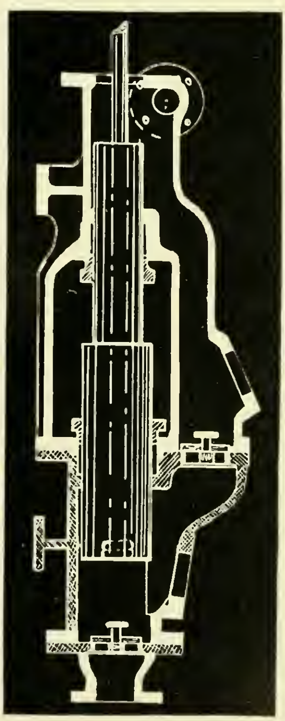

Fig. 2.

working in the Butte mines. The electric drive shown here to-night is still in our shops and is nearly completed and ready to go on the market in the near future.

[NOTE. — Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by June 15, 1909, for publication in a subsequent number of the JOURNAL.]

SEWERAGE STATISTICS.

Collected and Tabulated by the Sanitary Section of the Boston Society of Civil Engineers.

[Presented to the Sanitary Section of the Boston Society of Civil Engineers February 3, 1909, by a committee consisting of Harrison P. Eddy, Bertram Brewer and Charles Saville.]

On May 8, 1908, the Committee on Uniform Sewerage Statistics presented a report to the Sanitary Section accompanied with tabulations of such statistics relating to sewerage and sewage disposal as it had been able to procure for the year 1906, and this report was subsequently printed in the Journal of the Association of Engineering Societies, Vol. XL, No. 5, for May, 1908.

An attempt has since been made to secure the wider coöperation of city officials in preparing statistics for the year 1907, with the result that the accompanying tables include data from twenty-four cities and towns not included in the tables for the year 1906. These municipalities are as follows:

Brockton, Mass.
Buffalo, N. Y.
Cincinnati, Ohio.
East St. Louis, Ill.
Grand Rapids, Mich.
Harrisburg, Penn.
Holyoke, Mass.
Louisville, Ky.
New York City (Borough of Manhattan).
North Adams, Mass.
North Billerica, Mass.
Philadelphia, Penn.
Providence, R. I.
Pueblo, Col.
Rochester, N. Y.
St. Paul, Minn.
Salt Lake City, Utah.
Seattle, Wash.
Somerville, Mass.
South Bend, Ind.
Spokane, Wash.
Taunton, Mass.
Toronto, Canada.
Troy, N. Y.

The increase in the number of cities furnishing statistics is very encouraging, and it is to be hoped that there will be a still more general coöperation with the committee in furnishing statistics for 1908. It is unfortunate that the physical and financial records of the various cities are not so kept as to provide data for a greater proportion of the questions included in the Standard Summary.

Table showing Data (for the fiscal year 1907) relative to Sewerage and Sewage Disposal in Certain American Cities and Towns. Part I.

General

City or Town	Population (Census of 1905)	Total Area of City or Town [Sq. Miles]	Area Served by Sewerage System [Sq. Miles]	Collection System: For Sewage Only [Miles]	For Sewage and Surface Water [Miles]	For Surface Water Only [Miles]	Method of Disposal
Brockton, Mass.	47 794			53 10		14 3	Sand filtration
Buffalo, N. Y.	376 914	42 00	[illegible]		302 20		Niagara River
Cincinnati, Ohio	395 300	42 00	35 00				Ohio River
Dedham, Mass.	7 774	10 00	[illegible]	1 00			Metropolitan System
East St. Louis, Ill.	65 000	8 00	4 00		4 00		Cahokia Creek
Everett, Mass.	30 105	3 32	2 99				Metropolitan System
Fall River, Mass.	112 574	39 87	4 [illegible]		68 75		Tide Water
Fitchburg, Mass.	33 021	28 18	2 15		38.12		Nashua River
Gardner, Mass.	12 012	18 80	3 00	24 05			Settling tank and sand filters
Grand Rapids, Mich.	100 000	17 25		14 70	139 30	13 42	Grand River
Harrisburg, Pa.	50 167	7 75	4 00		54 83		Susquehanna River
Haverhill, Mass.	41 242	32 00	3 40	3 56	39 80	0 80	Merrimac River
Holyoke, Mass.	49 934	16 35	3 25		3 25		Connecticut River
Hopedale, Mass., Draper Co.	2 045	5 54	0 50	4 18			Septic tanks and sand filters
Hyde Park, Mass.	15 000	3 91	2 10	22 90	0 00	3.41	Metropolitan System
Laconia, N. H.	10 000			19 68		10 00	Lake Winnisquam
Lawrence, Mass.	76 616	6 75	3 00		64 00	0 36	Merrimac River
Louisville, Ky.	(k) 255 000	20 80			115 20	1 75	Ohio River
Lowell, Mass.	[illegible]	14 10	[illegible]	[illegible]	98 18	1 74	Merrimac River
† Nashua, N. H.	[illegible]		[illegible]		45 50	1 50	Merrimac River
New Bedford, Mass.	[illegible]	19		0 49	[illegible]	1 08	Tide Water 47 outlets
New London, Conn.	17 548	6 50	4 00	29 00	0 00	0 90	Tide Water
Newton, Mass.	36 827	18 00	6 68	101 00		54 83	Metropolitan System
New York City	[illegible]	21 [illegible]	21 9		518 00		Tide Water
[illegible] Mass.	[illegible]	20 04	1 10				Hoosac River
[illegible] Mass., Talbot Mills				0 88			Settling tanks and sand filters
Pawtucket, R. I.	[illegible]	[illegible]	21				Part to sand filtration Part into Seekonk River
[illegible] Pa.	[illegible]	[illegible]	90 00		1 003 00		Delaware and Schuylkill rivers
Plainfield, N. J.	18 478	5 90	3 98	14 [illegible]		3 28	Septic tanks and contact beds
Providence, R. I.	208 000	18 29				10 41	Chemical precipitation
Pueblo, Colo.	56 000	11 38	6 00	7 00		0 00	Arkansas and Fountain rivers
Rochester, N. Y.	181 666	19 73		3 02	1 00	1 75	
Salt Lake City, Utah	80 000	46 87	1 40	78 00			Part by broad irrigation, rest into Jordan River
[illegible] Mass.	[illegible]	54 0[illegible]	11 00		18 00		Tide Water
[illegible] Mass.	61 272	4 22		25 40	[illegible] 14	0 27	Metropolitan System
[illegible] Ind.	60 000	8 00	0 00				St. Joseph River
[illegible] Wash.		38 50	1 00		[illegible]		Spokane River
[illegible] Mass.	[illegible]	38 00	7 00	[illegible]	[illegible]	0 44	Connecticut River
[illegible]	[illegible]	55 54				1 64	Mississippi River
[illegible] Mass.	[illegible]	49 00	4 10	11 80		1 87	Taunton River
[illegible]	[illegible]	17 20	17 20	2 20			Part into Lake Ontario Rest treated in septic tanks and contact beds
[illegible]	[illegible]						Hudson River
[illegible] Mass.	[illegible]	3 56	2 70	11 50	12		Metropolitan System
[illegible] Mass.	[illegible]	4 16	2 00	13 06		8 45	Metropolitan System
W[illegible]	[illegible]	42 00	2 70	27 08		11 98	Westfield River
W[illegible]	[illegible]	38 4[illegible]	[illegible]	77 90	63 46	14 66	Chemical precipitation and [illegible] sand filtration

† Statistics for Manchester same as given in Vol. XL, No. 5

Collection (See Footnote *)

City or Town	Linear Feet Stone	Linear Feet Brick	Linear Feet Concrete	Linear Feet Pipe	Linear Feet Extended during Year	Number of Inverted Siphons	Number of Manholes	Number of Automatic Flush Tanks	Number of Direct Connections with Water Mains for Flushing	Number of Flushings of Entire System during Year	Cost of Flushing per Mile	Cost of Cleaning per Mile	Number of Stoppages	Miles of Permanent Under-Drains	Number of Storm Overflows
Brockton					21 091										
Buffalo	(a) 8 275	855 180	1 873	1 754 164	34 079	12	10 696					$301 25	101		21
Cincinnati					73 020	0		0	5					300 000	3
Dedham		3 160		(k) 73 345				1	57	1	(k) $17 25				
East St. Louis		3 000		160 000	40 000							225 00			
Everett		4 400 11 800 600	9 360	105 025 72 500 41 402	1 475 2 402	2	636 310 220		3	2 2	$1.5 00	5 00			2 1
Fall River	4 509	107 702 (c)	2 943	247 881	7 598		3 038						3		6
Fitchburg		24 166		177 091	11 330		931				1 00			0 00	0
Gardner				126 900	8 729	4	521	0	0	1	1 90		2	3 40	0
Grand Rapids		116 535	47 124	77 605 573 175 70 830			2 903	2							
Harrisburg	2 000	101 000	22 200	162 000	19 902	0	1 000	0	0	0			10	0 00	16
Haverhill	0 0 0	41 407	2 200 2 300	18 750 166 640 1 900	1 694 3 339	0 0 0	71 794 18	0	0					0 00	4
Holyoke	0	60 143	2 800	140 144 3 490	1 015 2 800	0		0	0					0 00	6
Hopedale				2 670	480		82								
Hyde Park	1 750		1 250	120 936 14 300	10 050 1 000		454 108	6		2		0 00	0		
Laconia				103 937	1 525	5	92	(d) 86		2	28 04		2		
Lawrence		104 758 1 531	400	233 242	6 073	1	1 201	0	0	0			22	0 00	11
Louisville					14 140 1 544	0 0 0		0 0 0	0 0 0						0 0 0
Lowell	6 125	167 003		6 270 350 625 9 213	1 005 5 111 872	0		0	5		6 60	470 00	0		9
Nashua	0 0 700	0 18 315 0	0 0 0	0 203 047 1 072	0 5 443 0	0 0 0								0 70	6
New Bedford	1 124	96 013	71	2 607 200 3[illegible] 5 708	18[illegible] 1 200	0 0 0	727 1	0 0 0	0 0 0	0 0 0	0 00 0 00 0 00	0 00 0 00 0 00	0 0 0	0 00 0 00 0.00	
New London		671		153 537	5 497	0	700 25	0					3		
Newton	14 167	55 668 34 400	4 547 17 600	483 710 224 128	10 326 6 001	1 1	2 678 693	0 0	180 0	0 0				85 04	3
New York	2 100 000			600 000	22 200		25 000	0	0	0				0 00	
[illegible]		1 064	681	133 890 35 848	1 893 2 522	1	605 221		1	2					1
[illegible] Talbot Mills				6 257			21							0 50	0 0 0
Pawtucket		11 069	1 031	238 077	7 805		1 132	121	180	3				1 70	
[illegible] Pa.		5 000 000	10 500	580 000	183 227	2									
Plainfield		1 250	3 695	220 714 22 021	20 874 136	1	[illegible] 18	125	11	11	19 56		2	2 42	
Providence		354 127 44 073	5 172	750 853 9 318	10 797 889	2	9 014	0	0		77 62		7	0 00	51
Pueblo		23 683		381 084 13 080	12 820 1 109	0 0	321 102	150				245 87		2 30	
Rochester								2		As needed		1 000 00			9
Salt Lake City		51 500		177 184	44 480	0	1 174	143	1	12	25 47		1		
[illegible]		70 806		925 952	83 720		3 146	200	0						
[illegible]	1 727	160 473	4 735	315 467	6 136 667 3 082	2	1 650					(b) 95 83	2	24 58	10
[illegible]		63 571	5 861	226 881	21 000	0		102	1						1
[illegible]		988	2 664	280 912	91 012	0	638	130	0					0 00	
[illegible]	2 519	113 725	4 451	970 429 208 2 311	20 721 1 611	1		1	391	26	19 52	12 78			15
[illegible]	3 500	173 [illegible]	7 280	926 430	65 126	0	4 664	28	0						
[illegible]		16 [illegible] 1 401		62 287 27 801 8 500	2 600	1	151			12	24 35			0 05	16
[illegible]		608 000		18 000 780 000	10 000	1	1 700	71							1
[illegible]		160 500		114 000				0							
[illegible]	2 098	9 575 6 900	1 753	100 880 53 818	1 580 61	3	881	0	115	2	1 07	5 58	7	0 57	
[illegible]		4 041	1 860	174 728 39 170	4 701 1 070	4 1	582 92	0 0 0	59	1		24 18	4	0 00	2
Westfield River				112 966	1 295	1	529					53 14			
W[illegible]	576 17 190	21 215 71 850 98 600 57 200	2 418 1 085	58 014 329 900 234 000 151 800	21 741 10 08[illegible] 2 710 1 00[illegible]	7 6	118 Total 6 771	7 2	[illegible] 54	All kinds	11 82 Total	46 48 Total	1	1 13	31

* A. For sewage only.
B. For sewage and surface water.
C. For surface water only.

(a) Miscellaneous, 20 633
(b) Special census
(c) Stone and brick
(d) 3 in use — unsatisfactory.

House Connections, Catch-Basins, Discharge of Sewage

City or Town	Method of Ventilation	By Whom Made	Sizes (Inches in Diameter)	Number Made during Year	Linear Feet Laid during Year	Linear Feet Discontinued during Year	Total Miles in Use	Average Cost per Foot of Connections Made during Year	Number of Stoppages Coming to Attention of Department	Number of Catch-Basins	Number of Catch-Basins Cleaned	Av. Amt. Material Removed per Catch-Basin (cu. yds.)	Cost of Removing Material per Cubic Yard	Cost of Removing Material per Catch-Basin per Year	Estimated Population Using System	Number of Buildings Connected	Daily Discharge for Year	Daily Discharge for Each User	Daily Quantity Factory Waste	Daily Leakage into Sewers	Daily Leakage per Mile of Sewer	Name of Person Furnishing Data
Brockton				330	15 562												1 174 205					
Buffalo	Perforated manhole covers	Licensed plumbers	6							4 578	23 701	0 04		$0.29	330 222							A. W. Hoffman, First Asst. Eng.
Cincinnati	Perforated manhole covers	Licensed sewer tappers	6	1 875	46 875		300 00	$0 75							300 000	27 250						
Dedham	Through plumbing system	Contractor	5	54			(k) 2.00	0 76	2	3						400						
East St. Louis		Plumbers	6																			W. J. Crocker, City Eng.
Everett	Perforated manhole covers	Licensed drain-layers	6	78	3 203		31 60	0 65		522	440	9.00	$0 55	5 00		4 578	2 875 000	96 0				
Fall River	Perforated manhole covers	Licensed drain-layers	6	116	2 000					904	1 746			4.64								P. D. Borden, City Eng.
Fitchburg	Perforated manhole covers	Supt. of Streets	5	110	4 600			0 30		730		3.50	0.80	2 80	25 000	2 900	(k) 2 900 000	(k) 116 0	Very little			
Gardner		Water Dept.	5	106	5 423	0	9.50	0 44	5	0	0	0.00	0 00	0 00	8 000	1 021						
Grand Rapids	Manholes and catch-basins	Plumbers	6 and larger	945																		
Harrisburg	Perforated manhole covers	Property owners	6	350						4 000	4 000	1.50	0 50	0.75	15 000	10 000	(k) 6 750 000	(k) 150.0	(k) 3 700 000	(k) 550 000	(k) 10 000	
Haverhill	Manholes and catch basins	Licensed drain-layers	5																			
Holyoke	Perforated manhole covers	City (within street lines)													52 000							J. L. Tighe, City Eng.
Hopedale		Draper Co.	4 and 6	7	260					0					2 250	220	144 000					
Hyde Park	Manhole covers and house connections	Contractors	5 and 6	122	7 080	50	11.14	0.55	0	106	200	2 single loads	0 70	1 75	8 850	1 780		(k) 160 0		(k) 400 000	(k) 18 000	
Laconia	House connections	Licensed drain-layers	4	55	2 785		9 02		10						8 000	1 000						
Lawrence	Perforated manhole covers	Licensed plumbers or contractors	6	185				0 50	42	1 153	2 475			2 70	69 000							
Louisville	Manholes	City (with street lines)	6	691							382				175 000							Mr. Lyman
Lowell	Manholes and overflows	Local contractors	5 and 6	215	7 500			0 50	39	3 387	3 387	1.00	1.40	1.35	94 000	11 200						G. Bowers, City Eng.
Nashua	House connections	Licensed drain-layers	4 to 8	45 0 17 c.b.						1 317	2 500	1.00			20 000							
New Bedford	Manholes and house connections	Sewer Department	5, 6, 8, 10	379	13 726	0		0.57	268	985	970	1 00		3 80	84 600	(b) 9 500						
New London	Perforated manhole covers	Property owners	6							127	127			7 00								W. H. Richards, Eng. Water & Sewer Dept.
Newton	Perforated manhole covers and house connections	City Contractors	5 and 6 6 and 8	113 0	8 000		60 02	0 68	134	2 352	6 800	4 00			20 000	5 272	(k) 3,000 000 Av. 6 000 000 Max. 1 066 000 Min.	(k) 106 0 Av. 212 0 Max. 38 0 Min.	Small			
New York	Perforated manhole covers	Licensed plumbers	6, 8, 10, 12	720						6 271	13 000	1.70	2.28	3 87	2 232 824							
[illegible]	Perforated manhole covers	City	4 and larger	36						238	238				(k) 15 000							
[illegible] Talbot Mills	Manhole covers	Talbot Mills	5												570	59						
Pawtucket	Manhole covers	Property owners	6	200	7 800		22 00			1 043	1 213	1 70	1 34	2 38	35 300	4 771						
[illegible] Pa.	Manholes	Property owners	5 and 6	11 000											1 250 000	250 000						
Plainfield	House connection and catch basin	Licensed plumbers	4	206				0.30	9	53	53	7 00			14 000	2 828	(k) 1 200 000 Av. 1 600 000 Max. 1 000 000 Min.	(k) 85 0	0	(k) 400 000 Max.		A. J. Garrett, City Surv.
Providence	Manhole covers	Licensed drain-layers	6	500				0 50	176	4 943	7 277	3 10	1 12	3 46	185 000		(k) 19 329 000 Av. 40 402 000 Max. 9 424 000 Min.					
Pueblo	Perforated manhole covers and ventpipes	Licensed plumbers	4 and 6	300	60 700	0		0 20		181					25 000	3 700						
Rochester	Gutter drains and manholes	Plumbers	6 and 9							Do not build them. Gutter openings only without trap					189 612		7 970 400 Av. 9 914 400 Max. 6 091 200 Min.	58 8 Av. 111 8 Max. 70 6 Min.	These quantities were measured, but include only 46% of population using the sewers			
Salt Lake City	Perforated manhole covers	Licensed plumbers	4 and 6	532	26 800		32 00		4						23 730	3 390	(l) 5 438 000 Av. 7 438 000 Max. 3 915 000 Min.	300 0		(k) 12 000 000 Av.		L. C. Kelsey, City Eng.
[illegible]	Manhole covers and house connection	Licensed sewer contractors	6	1 211				0 80		3 413	20 425			1 80								R. H. Thompson, City Eng.
[illegible]	Perforated manhole covers	Licensed drain-layers at property owners' expense	5, 6 and 8	227						1 541			1.00		71 000	(k) 13 658						
[illegible]	Manholes and house connections	Plumbers and sewer contractors	6			0		0 60	2	0	0	0 00	0.00	0 00	25 000							A. J. Hammond, City Eng.
[illegible]	Perforated manhole covers	Private contractors	6	700	19 000	0		0 75	3	234					25 000							J. C. Ralston, City Eng.
[illegible]	Manholes and house connection	Sewer Department	6 and 8	521	13 025			0 35														A. A. Adams, Supt. Streets and Sewers
[illegible]	Perforated manhole covers	Licensed drain-layers (paid by parties benefited)	6	1 324						5 00[illegible]	7 148	2 00	0 78	2.17								
[illegible]	Perforated manhole covers	City	5	45	2 116			0 55		185					15 000	1 684						
[illegible]	Manholes	City	6 and 9	2 300	74 000			0 88		10 000	10 000				262 749		(k) 28 000 000					
[illegible]		Licensed plumbers								2 000	1 000	2 00	1.35		50 000							
[illegible]	House connection	City	4 and 5	138	7 048	0	11 72	0 38	77	385	730			3 60	26 000	3 291						B. Brewer, City Eng.
[illegible]	House connections	Town	4 and 5	34	1 592	0		0 88	35													
Westfield River	Manholes	Plumbers	4, 5, 6	29						554	554			0 87	12 560	1 848						
W[illegible]	Perforated manhole covers on hill tops	Licensed drain-layers	6	521 113	13 747 5 374		122 50 All kinds	0 50 All kinds	32	2 002	4 804	3.04	0 81	2 48	122 300		15 560 000	127 2		3 224 000	23 130	

(e) Special census, 1907.
(g) 1900 census.
(h) Including catch-basins.

(i) 1907 census.
(k) Estimated.
(l) Measured.

Table showing Data (for the fiscal year 1907) relative to Sewerage and Sewage Disposal in Certain American Cities and Towns. Part II.

Pumping

City or Town	Description of Plant	Coal: Kind	Coal: Brand	Coal: Av. Cost per Gross Ton Delivered	Coal: Per Cent of Ash	Fuel for Int. Combustion Engines: Kind and Grade	Fuel: Av. Cost per Gal	Electricity: Av. Cost per K.W. Hour	Yearly Amount of Fuel or Power Used	Total Pumped for Year	Av. Static Head	Av. Dynamic Head	No. of Gal. Raised One Foot per Unit of Fuel or Power	Cost of Pumping
Brockton Mass	[illegible]								327 000 lb	1 174 205		72		
Buffalo N.Y.	[illegible] Sewage Pumping Station [illegible]	[illegible]				About [illegible] of steam is obtained from [illegible]				8 000 000 000 without	13 00	14		$0.01
East St. Louis Ill.	Small pumping plants operated only during high stages of Mississippi [illegible]													
Everett Mass	[illegible] has 7 connections [illegible] Met. sewer [illegible] trunk line [illegible]													
Gardner Mass														
Hopedale Mass	[illegible]	Power furnished by [illegible] power plant of the Draper Company								50 000 000	22 00			
Marlborough Mass	[illegible]	[illegible]			$3 10				11 [illegible] tons	3 244 350 without	56 00	78	7 700 gal per lb coal	0.2
[illegible] Mass	[illegible] centrifugal pumps, operated by 2 [illegible] h.p. gasoline engines					2 [illegible]	[illegible]		1 [illegible] gal	11 [illegible] 307 with	24 75	35	283 700	1 08
[illegible] Mass														
[illegible] R.I.														
[illegible] N.Y.	[illegible]							$0 10						
[illegible] R.I.	[illegible]	[illegible]			[illegible]				1 732 sh. tons	[illegible] with	[illegible]	31	[illegible]	2.90
Salt Lake City Utah	[illegible]	[illegible]			7 50			0 01						
St Paul Minn								0 20						
Toronto Canada								0 03	41 000 k.w.h.					
Waltham Mass	[illegible]													
[illegible] Mass	[illegible]							0 05	2 [illegible] k.w. [illegible]					

Disposal

City or Town	Description of Screens	No. of Tanks: Settling	Septic	Chem. Precipitation	Total Capacity of Tanks up to Flow Line	Av. Daily Quantity of Sewage Treated (Gallons)	Av. No. of Hours Sewage is in Tank	Disposition of Effluent	Disposition of Sludge	Cu. Yd. Sludge produced per Million Gal. Sewage	How Often are Tanks Emptied?	Cost of Tanks	Cost of Maintenance, including Cost of Disposition of Sludge	Kinds and Quantities of Chemicals used per Million Gallons
Brockton Mass	Iron plates [illegible] spaces [illegible] sq. ft.	1			600 000	1 174 205		Conweset River	Used for fertilizer					
Buffalo N.Y.														
East St. Louis Ill.														
Everett Mass														
Gardner Mass		6						Otter River	Fertilizer for sewer farms	Old 100 New 300	Old, once per 14 d'ys New once per 60 days	$7 033 00	$1 156.34	
Hopedale Mass	[illegible] cloth	Pump wells Tanks	2		72 000 58 270	114 000	15	Pumped to filter beds, then Mill River	Carted off as necessary					
Marlborough Mass	Perpendicular bars [illegible] Screens & tanks b't'n [illegible] sewage flows up [illegible]	2			8 100	582 000	Normal, 45 min.; freshet, 30 min.	Runs by gravity to filter beds	Sludge beds	1 300 gal	Once per week		949.35	None
[illegible] Mass	Basket screens [illegible] dia. [illegible] deep, w. w. [illegible] mesh													
[illegible] Mass											Every 2 weeks	305.20	4 10 per cleaning	
[illegible] R.I.					136 418	249 107	1 hr	Intermittent filtrat'n thru sand beds	Deposited in trenches and cov'r'd with earth	8.2		3 500 00		
[illegible] N.Y.			1		1 [illegible] 000	1 200 000	18 hr	Flows over weir to contact beds	Used for fertilizer	93 cu ft	Once per year		712 84	None
[illegible] R.I.	Trash racks, [illegible] deep, 11' 3" long, kept clean by hand raking	Houghton 4		10	11 [illegible] 000	18 573 000		Into tide water under [illegible] of water	Used for filling	1 500 gal		Total 90 [illegible]	44 795 00	Lime [illegible] lb. Cop'ras [illegible] with [illegible] lb lime per 1 000 gal. sludge
Salt Lake City Utah														
St Paul Minn														
Toronto Canada			1		154 000	550 000		Lake Ontario			Twice yearly	22 000 00 (b)	2 000 00	
Waltham Mass														
[illegible] Mass	Small basket vertical rods [illegible] screens with Shone systems		for [illegible] purp	10	[illegible] 000	[illegible] 000	4 to 8 hr	Blackstone River	Pressed dumped in cake form	5 203	Avg every 6 weeks	355 028 75	44 291 21	[illegible] lb. Lime

Sewage Beds or Filters

City or Town	Type	Date of Construction of Works	Cost of Beds	Total Net Filtration Area (Acres)	Number of Beds	Average Area of Beds (Acres)	Were Loam and Subsoil Removed?	Character of Filtering Material Effective Size (mm.)	Underdrains: Depth	Underdrains: Distance apart	Average Daily Quantity of Sewage Treated	Average Daily Quantity of Sewage Treated per Acre (Net Area)	Maximum Daily Quantity of Sewage Treated (Gallons)	Preliminary Treatment	Dosing Apparatus and Size of Dose (Gallons)	How Long does Sewage flow on one Bed?	How often is Each Bed used?	Method of Caring for Surface of Filters	Cubic Yards of Material Removed from Surface of Beds	[illegible]	Are Crops Raised? What Kind	[illegible]	Total Cost of Maintenance	[illegible]	[illegible]
Brockton Mass	Sand filters	1893-4		6 77	37	97	Yes	Average .[illegible] mm		45'-55'	1 174 205	31 700	1 757 000	Passed through reservoir	None			All cleaned in spring. Sludge beds. Beds furrowed in fall, leveled in spring	4,1[illegible] tons						
Buffalo N.Y.																									
East St. Louis Ill.																									
Everett Mass																									
Gardner Mass	Sand filters	Old 1891-2-3 & [illegible] New 1901-4	$55 075 00	Old 2[illegible] New 3	Old 30 New 12	Old [illegible] New 1	Yes		Old r [illegible] Tem. 3½'	30' 27'				Temp'ry tion area settling tanks and coke beds		By day 6 hr; by night 1 hr	Every other day	Once each year	Old works [illegible] New works 1 [illegible] yd	Old works $[illegible] New works $[illegible]			[illegible]		
Hopedale Mass	Sand filters	1900		2 85	6	0.57	Yes	Fine sand, gravel around underdrains	[illegible]	30'	144 000					2 hr	Once in two days	Raked, plowed, furrowed in fall. Raked, leveled in spring							
Marlborough Mass	Intermittent sand filters	1890-92	31 647 00 (a)	11 2	Sewage 18 Sludge 6	0 5	Yes	Average eff. size .34 mm	5' to 8' deep	60'	582 000	52 000	1 000 000	Passed through settling tanks and screens	30 000 gal	8 to 16 hr Max 24 hr	4 doses per m. from [illegible]	[illegible] & harr'd spr. & fall. Plow'd spr. [illegible] & crops cared for in summer	1 1[illegible] cu yd	1 20 Teaming	Small [illegible] corn				
[illegible] Mass																									
[illegible] Mass			6 043 00																	80 00					
[illegible] R.I.	Sand filters. Str'n used in w'nt'r, sl'dge beds in s'm'r	1894	Land 16 [illegible] 00	5.36	16	⅓	Yes	E. S. 0.17 mill. [illegible]	4.5' to 5.5'	20'	142 815	42 520	670 000	Scr'n'g & settl'g tanks in w't'r; settl. tanks only in summer	Dosed by hand; potato rate of [illegible] gal per acre	One dose only	W. 36 [illegible] gal daily; S. 53 [illegible] gal daily	Scraped spring & fall. Furrowed in winter. Raked when necessary	[illegible]	1 377 00					
[illegible] N.Y.	Contact beds, [illegible] stone, slag and clinkers	1895 1902 1905	92 000 00 excl. engineering	3 52	16	0 22	Yes	1" to 1½"	[illegible] tile radiating from gate chamber		1 200 000	340 000	1 000 000	Septic	None	2 hr	Twice per day	Raked occasionally. Top surface replaced as necessary		[illegible]	[illegible]	[illegible]	[illegible]		
[illegible] R.I.																									
Salt Lake City Utah																					[illegible]	[illegible]			
St Paul Minn																									
Toronto Canada	Intermittent contact beds, using slag	1906		0.37			No	Slag			550 000	30 000		Septic		4 and 5 hr									
Waltham Mass																									
[illegible] Mass	Intermittent sand	1890-1897	57 225 46	71.5	52	0 99	Yes	14 beds, 23 mm; 9 beds, 16 mm; 8 beds, 20 mm	4 to 6	50' 40	3 000 000	72 000	12 180 000	Passed through grit chamber	Molasses gate at distributors	[illegible] hr	1 to 4 times per week	Raked or redistributed [illegible] weeks. Rest of bed once in 4 to 8 weeks	1, 2[illegible]	[illegible]	None		[illegible]	[illegible]	

(a) Including land

(c) Beds and pumps

* Total cost of maintenance [illegible] Disposal Works

Mention should also be made of the fact that the data supplied for the year 1907 have not in some cases checked up as they should with those for 1906. This matter, however, is one which can be easily remedied in the future by the use of a little more care in the preparation of the statistics.

While the information collected is of much value, the most beneficial results of the work of the committee should be the establishment of improved systems of recording important data, and the committee takes this opportunity of urging upon city officials having charge of, or connection with, sewer departments, the importance of keeping their records in the form suggested by this Society, so that they may always be available. The statistics which might thus be obtained will be of great value to engineers and officials generally, but of much greater value to the local officials in charge because of the more intimate and accurate knowledge which they will have of the important data relating to their respective departments.

It has been hoped that the Summary of Sewerage Statistics would be more generally adopted and printed in the annual reports. It has been adopted and forms a part of the annual reports of the cities of Cambridge, Newton, Waltham, Watertown and Worcester in Massachusetts, and the city of Providence in Rhode Island.

The committee having this work in charge takes this opportunity of expressing its appreciation of the assistance rendered by the various city officials who have contributed data for the year 1907 relating to the sewerage systems with which they are connected.

The information which has been obtained from forty-eight cities and towns in Massachusetts and other states has been summarized in the accompanying tables, which are self-explanatory. It will be noted that the three tables similar to those published for the year 1906 have been supplemented by a fourth, in which the information relating to the maintenance of sewers has been rearranged in such a manner as to make it possible to compare the relative cost of caring for sewerage systems in the several municipalities from which information of this sort has been received. Many of the data in the table are included in the information furnished by the municipalities heard from, but it has been found possible to supplement this by additional information obtained from printed reports, articles in engineering periodicals, etc.

It is expected that the Society will publish similar data

for subsequent years, and suggestions relative to the best method of arranging and tabulating this information will be welcomed. Officials who are willing to coöperate in this work are respectfully urged to adopt means of securing as many as may be possible of the data specified in the standard Summary of Sewerage Statistics.

Statistics for 1907.

It has been found best to summarize the information obtained relative to the materials used and the methods employed in the several municipalities for the flushing and cleaning of sewers as follows.

Flushing.

Thirty-four use direct or hose connections with water mains; of these, six use automatic flush tanks also, while one, to a certain extent, makes use of the waters of a convenient pond.

Two use automatic flush tanks exclusively.

Two use storm water from catch basins or other receptacles.

Others do not report any regular method of flushing.

Cleaning.

In twelve municipalities water alone, in large quantities and under pressure, is all that is used to clean the sewers. In few cases do the authors of these reports fail to state that, in conjunction with mechanical devices of all kinds, large quantities of water are used. The following mechanical devices are mentioned: Jointed rods, rope, chain, the Healey and other sewer cleaning machines, steel buckets, scrapers and drags of various kinds, cylindrical scrapers, root cutters, brushes and wooden balls. Men, horses or engines, and wrenches and hoists of various kinds are all used, as the quantity of work to be done and the size of the plant requires. In several cases this work is only done when there is a stoppage; in one case the sewers are constantly cleaned; in most cases it appears that only such cleaning as is necessary is done, after a more or less careful inspection has been made.

Assessments.

Methods of assessing the abutters and the rates of assessment have also been reported. The custom commonly followed in this matter of assessment appears to be that of charging the abutters according to the length of frontage along the line of sewer together with a certain amount per square foot on all land

TABLE SHOWING DATA (FOR THE FISCAL YEAR 1907) RELATIVE TO SEWERAGE AND SEWAGE DISPOSAL IN CERTAIN AMERICAN CITIES AND TOWNS. PART III.

FINANCIAL

CONSTRUCTION

City or Town	Receipts: Balance of Previous Year	Receipts: Bonds Issued	Receipts: Appropriation	Receipts: Assessments	Receipts: House Connections	Receipts: Other Sources	Receipts: Total	Expenditures, Collection Works: Mains	Expenditures, Collection Works: House Connections	Expenditures: Disposal and Purification Works	Balance	Total
Brockton, Mass.						$10 088 69	$67 766 83	$46 905 25				$68 109.55
Everett, Mass.												
Fitchburg, Mass.	$375 14	$12 500 00		$11 205 07	$1 320 12	6 80	25 407 43	$24 693 54			$713 89	25 407 43
Gardner, Mass.	7 385 35	11 500 00					18 885.35	18 768 65			116 70	18 885.35
Harrisburg, Pa.			$73 000 00				73 000 00	73 000 00				73 000 00
Haverhill, Mass.		10 000 00				456 43	10 456 43	5 610 08		*$1 368 73	3 477 62	10 456 43
Hyde Park, Mass.	818 80	30 000 00	2 000 00	5 183 76		462 00	38 464 56	38 250 00	150 00		64 56	38 464 56
Laconia, N. H.	46 41		75 00				121 41	(b) 97 31			24 10	121 41
Lawrence, Mass.		75 000 00	13 500 00	4 823 54	Transferred 12 500 00	Overdraft 3 947 16	109 770 70	60 726.53	Manholes in old sewers 118.20	New catch-basins 3 655 66	23 253 91	87 754 36
Marlboro, Mass.	4 080 16				1 020 47	3 07	5 089 70	3 535 60	886 00		668 10	5 089 70
Nashua, N. H.			9 665 32				9 665 32	9 665 32				9 665 32
New Bedford, Mass.												
New London, Conn.												
Newton, Mass.	12 141 88	Money advanced 28 110 21		15 149.15	2 500 00 + 1 805 40	Stock transferred 7 437 55	70 143 64	49 256 68	5 463 91	Stock purchased and transferred 7 437 55	Stock 6 144 01 House connections 1 841 49	70 143 64
North Adams, Mass.			7 000 00		830 00		7 830 00	6 728 42	180.78		920.80	7 830 00
Pawtucket, R. I.	5 835 48		21 725 00	6 341.16		609 75	34 511 43	21 969 89		Catch-basins 169.25	12 372 25	34 511.43
[illegible]												
Plainfield, N. J.												
Providence, R. I.		50 000 00		45 884 47		2 000 07		94 951.46				94 951 46
[illegible] City	[illegible]		2 000 54	67 277 55	1 671 00	230 68	205 626 27	204 009.97	1 616 30			205 626 27
[illegible]			6 154 41	421 347 75				347 502 18				
[illegible]	451 [illegible]		[illegible]	[illegible]		1 692 88	29 853 98	27 813 08	C. Bs Conn 2 409 96		Overdrawn 369 01	29 853 98
[illegible]												
[illegible]			45 [illegible]	Interest [illegible]	5 464 15	1 003 57	†66 755 95	44 764 43	4 588 78			49 354 21
[illegible], Mass.	[illegible] 028 68	[illegible]	10 000 00	[illegible]	1 903 00	1 023 90	414 635 95	228 284 71	4 222 72		182 128 52	414 635 95
Taunton, Mass.	2 697 [illegible]					1 187 92	28 356 99	25 048 04			3 308 97	28 356 99
Waltham, Mass.	18 0[illegible]		[illegible]		5 841 79		24 661 72	11 841 43	3 524 38		9 295 91	24 661 72
Watertown, Mass.	[illegible]		[illegible] 000 00		200 95	169 56	7 501 86	5 282 20	1 405 35		4 32	
W[illegible], Mass.	[illegible]		[illegible] 00			211 58	21 060 34	13 788 06			7 277 47	21 066 33
[illegible]	[illegible]		60 000 00	[illegible] 63		11 000 00	121 788 24	67 843 63		30 312 28	17 612 33	121 788 21

MAINTENANCE AND OPERATION

City or Town	Receipts: Balance of Previous Year	Receipts: Appropriation	Receipts: Assessments	Receipts: Other Sources	Receipts: Total	Expenditures: Administration	Repairs	Cleaning Sewers	Cleaning Catch-Basins	Flushing Sewers	Pumping	Disposal or Purification‡	Unclassified Expenses	Balance	Total
Brockton, Mass.			Rentals $51 098 16 13 000 00	$911 52	$69 788 43	$18 080 89									$68,859 64 Including Bonds
Everett, Mass.															
Fitchburg, Mass.		$3 000 00		1 791 29	4 791 29		$228 03		$3 841 34	$397 96			$323 96		4 791 29
Gardner, Mass.	$149 16	1 200 00		99 22	1 748 38					42 30		$1 575 00	38 05	$92 04	1 748 38
Harrisburg, Pa.		6 700 00			6 700.00		3 700 00		3 000.00						6 700 00
Haverhill, Mass.		500 00	1 097 48	985 93	2 583 41								2 583 41		2 583 41
Hyde Park, Mass.	Part Highway Appropriation Part Sewer Funds					350 00	25 00		185 00	150 00					710 00
Laconia, N. H.	0.22	1 000 00	Permits 245 00	33 35	1 278 57	504 23	174 04			572 29				78 01	1 278.57
Lawrence, Mass.	Construction and Maintenance accounts are lumped together, except where moneys raised for special purposes					13 030 82	1 135 27	$267 75	6 682 50						22 016.34
Marlboro, Mass.		2 000 00		Rentals 8 821 20	10 821.26						$61 29	1 312 27	626 44	8 821 26	10 821 26
Nashua, N. H.		60 71			60.71			60 71							60.71
New Bedford, Mass.															
New London, Conn.															
Newton, Mass.		9 000 00	Receipts 447 19	Tax Levy 11 457 91	20 905 10	321 84	3 306 41			1 400 00	378 90	11 457 91 Met. W'ks $103 054 33	Materials in Stock 3 267.39	1 074 66	20 905 10
North Adams, Mass.		5 000 00		Overrun 450 27	5 450.27		5 450 27								5 450.27
Pawtucket, R. I.		21 076 79		1 066 67	24 721.96	2 578 50	130.02		2 888 48	1 302 90		8 779 82	8 956 10	86 13	24 721.96
[illegible]															
Plainfield, N. J.		5 100 00		458 65	5 558 65	1 200 00	138 71		Ch'g'd to Street Acct	817 34		2 524 13	680 17	189 27	5 558 65
Providence, R. I.		125 000 00		7 833 93	132 833 93			11 303 57	17 106 00		19 320 39	44 795.32			92 525.28
[illegible] City		4 058 97		Rentals 50 00				335 77		2 061 51		20 40	1 641 35		
[illegible]							930 89	2 222 35	6 294 60				367 69		
[illegible]		12 000 00		242 35	12 242 35	773.55	1 691 36	2 507.60	6 798 80	Inspection 330 08			212 [illegible]	Overd'n 81.39	12 242 35
[illegible]															
[illegible]						2 505 60	3 248 82 Tools, etc. 2 328 71	Teams, City Yard Engineering 2 122 30 1 415 71	820 86	2 134 67	Work Ch'geable 2 705 99		509 66	323 28	66 755 95
[illegible], Mass.		27 078 28			27 078 28	1 886 67	7 000 73	5 850 25	9 119 12	1 027 02	854 10		350 39		27 078 28
Taunton, Mass.		1 200 00	Rental 2 400 00	2 002 07	5 602 07	1 035.91			595 59	608 81				2 461.76	5 602 07
Waltham, Mass.		9 810 86			9 810 86	353 25	787 80	210 17		166 68	27 33	8 010 86	20 00	201.57	9 810 86
Watertown, Mass.	See Construction Receipts							809 99	Plus "Collection Works" Expenditures						7 501 86
W[illegible], Mass.	121 70	1 500 00		315 00	1 936 85			1 439 03	315 09					182.73	1 936 85
[illegible]	113 82	98 700 00		1 205 05	103 048.87	2 113 61	6 269 98	6 478 15	11 008 91	1 617 68	5 315 75	57 889 31	11 189 54	5 91	103 648.87

GENERAL

City or Town	Interest on Bonds	Sinking Fund	Total Cost Collecting Mains	Total Cost Pumping Station	Total Cost Disposal Works	Total Cost Works to Date	Bonded Debt at Date	Value of Sinking Fund at Date	Average Rate of Interest on Bonds Per Cent	Per Cent Cost of System as Assessed on Abutters
Brockton, Mass.	$21 578.75		$539 208.14		$272 983 07	$951 030 04				
Everett, Mass.			648 254.00				$140 000 00	$183 078 00	4%	50%
Fitchburg, Mass.		(a) $9 105 00	407 671 00			407 671 00	83 235 00	90 100 00	3½ to 4%	75%
Gardner, Mass.			239 275 30		62 108 00	301 383.30	160 800 00		3½%	95%
Harrisburg, Pa.			800 000.00			800 000.00				35%
Haverhill, Mass.										35%
Hyde Park, Mass.										
Laconia, N. H.			120 058 31			120 058.31			4%	
Lawrence, Mass.			1 211 411 00			1 211 411 00	212 500 00		4%	22.8%
Marlboro, Mass.	11 480 00	10 160 00	353 029.37	Pump'g sta. $860 00	38 611 06	392 300 43	287 000 00	182 551.38	4%	
Nashua, N. H.										
New Bedford, Mass.			1 165 628 47			1 165 628 47				50%
New London, Conn.						315 833.24	85 000 00			70%
Newton, Mass.			1 815 103 06	6 700 00		1 821 803 06	1 388 000 00	699 646 78	[illegible]	36.7%
North Adams, Mass.	3 770.93						107 000 00		3½%	
Pawtucket, R. I.	34 800 00	24 772 78	Construction 969 998 09	Maintenance 202 962 83	15 630 34	1 208 589 26	875 000 00 Floating Debt 20 000 00	160 460 89	4%	
[illegible]			Main Sewers 13 727 666 16	Branch Sewers 12 884 438 94		26 612 105.10				
Plainfield, N. J.	Bonds Retired 4 000 00 5 000 00 Int. on Notes 5 286 87		217 144 00	4 000 00	143 487 00	364 631 00	Bonds to be sold 65 000.00 Sanitary only 121 000 00 Other Notes 41 700 00		4%	70%
Providence, R. I.	213 000 00	2 034 759 58	7 449 678 86	278 054 24	Land 114 081 15 99 155 60	8 280 969.85	7 845 000 00		4%	[illegible]
[illegible] City			1 228 711 86	69 922 84	50 000 00	1 348 704 70	3 798 000 00		4%	
[illegible]			2 306 782 95			2 306 782 95	2 245 000 00		4½%	
[illegible]	9 137.50		Dr'nage Syst'm 1 206 241 00				290 000 00	Serial plan	3½%	40%
[illegible]			627 431.00						3½ to 4%	
[illegible]	6 832 50	35 000 00	1 391 908 47				195 000 00	26 271 79	3½%	[illegible]
[illegible], Mass.	65 550 00	15 000 00	2 300 000 00	4 500 00			1 540 000 00	15 000 00	4½%	[illegible]
Taunton, Mass.			427 820 96			427 820 96	430 000 00	147 438 94	4%	
Waltham, Mass.	26 427.47	7 221 85	434 341 05	7 171 00	Metropolitan	441 512.05	207 000 00	85 806 06	4%	[illegible]
Watertown, Mass.			282 072 83		Met. sewer tax 100 084 76	382 157.59	67 500 00		4%	
W[illegible], Mass.			364 391.58				144 000 00		3½ to 4	
[illegible]	65 385 00	29 453.26	4 086 106.03	33 371 50	634 000 00	4 753 477 53	1 771 000 00	592 589 29	3.5%	[illegible]

* Paid 1906 overdraft.

† $14 314 37 of this amount to be provided by issue of bonds in 1908.

‡ Interest, etc.

(a) And loan.

(b) Much of sewers built during year paid for by private parties.

sewer together with a certain amount per square foot on all la

Table of Data Relating to the Maintenance of Sewerage Systems.

City or Town	Population: Population	Population: Year	Date and Period for which Data is given	Length of Sewers (Miles): For Sewage Only	Length of Sewers: For Sewage and Storm Water	Length of Sewers: For Storm Water Only	Length of Sewers: Total: Items 5 and 6	Length of Sewers: Total: Items 5, 6 and 7	Flushing: Number of Flushings of Entire System per Year	Flushing: Cost: Per Mile	Flushing: Cost: Based on Item	Cleaning: Number of Miles Cleaned	Cleaning: Cost per Mile	Cleaning: Based on Item	Flushing and Cleaning: Cost per Mile	Flushing and Cleaning: Based on Item	Catch-Basins: Number Cleaned	Catch-Basins: Cost per Catch-Basin per Year	Catch-Basins: Number of Cubic Yards Removed per Catch-Basin	Catch-Basins: Cost per Cubic Yard	Expenses for Repairs	Administration Expenses	Unclassified Expenses	Maintenance: Total Cost: Cost	Maintenance: Total Cost: Includes Items	Maintenance: Cost per Mile: Cost	Maintenance: Cost per Mile: Based on Item	Source of Information	Remarks
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28		
I. Cities and Towns Having Sewers Built on the Separate System.																													
Arlington, Mass	9 668	1905	1906	26.70		6.20		32.90	6	$0.75	5		$4 00	5	$4.75	5		$2 00	4	$0.50				$678.02	16 & 19	$20 63	9	" Uniform Sewerage Statistics "	
Concord, Mass.	5 421	1905	1908	7.81			7.81		2						*23.30							$375.00	$802.86						* For 1904
Framingham, Mass	11 548	1905	1908	17.30			17.30		2	12.23	8										0.00		0.00	*211.66	11	12.20	8	Town officials (personal conference)	* $116.13 of this paid to water dept. for water used in flushing; includes part of foreman's salary.
Gardner, Mass	12 012	1905	1906 & '07 (Average)	23.77			23.77		1	*1.90	8												50 73	165.86	11 & 24	7.02	8	" Uniform Sewerage Statistics "	* For 1907 only
Malden, Mass	38 037	1965																								5.00		Jour. Asso. of Eng Soc., Oct., '04	
Marlboro, Mass	14 073	1905	1908	25 00			25 00		12	19.37	8										$100.00	0 00	*139.36	723.50	11, 22, & 24	28.94	8	City officials (personal conference)	* New manhole covers
Melrose, Mass.	14 295	1905					35.30		1	17.00	8																	Jour. Asso. of Eng Soc., Oct., '04	
Natick, Mass	9 609	1905	1905, '06, '07 (Average)	*13.03			*13.03			7.95	8										†33.25			128 70	11 & 22	9.87	8	Town officials (personal conference)	* 1908 † New manholes
Newton, Mass	36 827	1905	1906 & '07 (Average)	102.80			102 89	157.15	13	*9 80	5		*27.50	7	*37.30	5	6 841.0				†3 702.77	364.16		5 256 02	16, 22, & 23	33.44	9	" Uniform Sewerage Statistics "	* 1906 only. † Includes cost of cleaning sewers
Plainfield, N. J	18 478	1905	1906 & '07 (Average)	38.97			38.97	44.21	10 to 30	19 95	5						53.0				*149.11	(a) 1 200.00	(b)588.14	(c)2 713.36	16, 22 23 & 24	61.40	9	" Uniform Sewerage Statistics "	(a) (b) (c) See Pawtucket * Includes cost of cleaning sewers
Pueblo, Col	*56 000	1905	1907	73.00	8.50		81.50								45 87													" Uniform Sewerage Statistics "	* Estimated
Quincy, Mass	28 070	1905							8 or 9	37.50														1 500.00	16			Jour. Asso. of Eng. Soc., Oct., '04	
Salt Lake City, Utah	80 000	1907	1907	78.00			78.00	78.00	12	25 47													1 641 35	4 038 57	10 & 24	51.79	9	" Uniform Sewerage Statistics "	
Waltham, Mass	26 239	1905	1906 & '07 (Average)	41 42			41.42	54.07	2	4.26	5		3 88	5	10.10	5	730.0	*3.00			720.78	335 29	53.63	1 520.50	16, 19, 22, 23 & 24	28.11	9	" Uniform Sewerage Statistics "	* 1906 only
Watertown, Mass	11 202	1905	1906	32.39		8.11	32.39	40.50	2	5.30	5													716.85	16 & 22	17.71	9	" Uniform Sewerage Statistics "	
Westboro, Mass	5 378	1905	1908	9.00	0.00	0.00	9.00		5 or 6*	0.73	8	0.50	30.00	13	2.40	9					0 00	0.00	0.00	21.00	16	2.40	8	Town officials (personal conference)	Cost figures are estimated * Part of system only.
Westfield, Mass.	13 609	1905	1906 & '07 (Average)	26.96		11.54		38.50					53.17				436.0	0.46						1 681 45	14 & 10	43.67	9	" Uniform Sewerage Statistics "	
II. Cities Having Sewers Built on the Combined System.																													
Buffalo, N. Y	376 914	1905	1907		502 20		502 20						304 25	6			23 701.0	0.29											
Cambridge, Mass	97 134	1905	1907	19 48	110.22	6.07	129 70	135.77									1 948 0	2.54	2.41	1 41	5 711.33	4 204.85	1 529 46	19 400.20	16, 19, 22, 23 & 24	143.60	9	" Uniform Sewerage Statistics "	
Fitchburg, Mass	33 021	1905	1906 & '07 (Average)		37 05		37.05	37.05		*1.00	9							2.73		0 79	367.55		297.50	4 899.48	11, 19, 22 & 24	132.37	9	" Uniform Sewerage Statistics "	* 1907 only
Lawrence, Mass	76 716	1907	1906 & '07 (Average)		63.50	0.55	63.50	64.05	0								2 657.0	4 37	*2.00	*6.93	902.86			*11 688 30	19, 22, 23 & 16	263.75	9	" Uniform Sewerage Statistics "	* 1906
Lowell, Mass	94 889	1905	1906 & '07 (Average)	1 09	97.71		98 80	100.42		4.27		0 47	3.60	13		8	3 376.0	1.43		1.20								" Uniform Sewerage Statistics "	
Lynn, Mass	77 042	1905					75.00			133.00	8													10 000.00	11			Jour. Asso. of Eng. Soc., Oct., '04	
New Bedford, Mass	70 078	1906	1906 & '07 (Average)	0 46	73.35	0 96	73 81	74.78	0	0.00			0.00		0 00		957.0	3.70	4.00	*0.90	*44.83	*1 006.76		4 599.21	19, 22, 16 & 23	61.50	9	" Uniform Sewerage Statistics "	* 1906 only
Pawtucket, R. I	43 381	1905	1906 & '07 (Average)		52.61		52 61	52 61	3	†0.45	6		†0.37	6	0.82	6	1 188.0	*1.10		*2.07	427.85	(a)2 353 30	(b)4 898 37	(c)12 292 18	14, 16, 19 22, 23 & 24	232.65	9	" Uniform Sewerage Statistics "	* 1904, '05, '06 and '07 † 1906 only (a) Includes disposal (b) May include disposal (c) Includes administration expenses for both sewers and disposal works
Providence, R. I	208 000	1907	1903, '04 '05 '06 & '07 (Average)					203.06				298 20	927.80	13			11 193.0			*1.40				57 151.20	14, 19, 22, 23, & 24	281.00	9		*Includes cost of cleaning sewers
Rochester, N. Y	181 666	1905	1907	3.02	249 00	1 73	252.02	253.75					1 000.00																
Springfield, Mass	75 000	1906	1906 & '07 (Average)	0 18	108.15	0 28	108.33	108.61	26	19.00	6		14 43	6	34.33	6					5 724 33	2 440 11	2 550.68	17 588 85	16, 22, 23 & 24	162.55	9	" Uniform Sewerage Statistics "	
III. Cities Having Sewers Built on Both the Separate and Combined Systems.																													
Boston, Mass	595 380	1905											*924 00															Jour. Asso. of Eng. Soc., Oct., '04	* Large brick sewer
Everett, Mass	29 340	1906	1906 & '07 (Average)	*890 00	*440 00	*500 00	*1 330.00	*1 830.00	4	12.92	5			8	64 02	8	440.0	5.00	0 00	0.54							9	" Uniform Sewerage Statistics "	* Drainage area (acres)
Somerville, Mass	69 272	1905	1907	23 40	67 44	6 27	90 84	97.11							*95 83	6				1.00	1 601 36	773 55	242 35	11 852.70	10, 19, 22, 23 & 24	122.10	9	" Uniform Sewerage Statistics "	* Includes cost of cleaning catch-basins
Taunton, Mass	30 967	1905	1908	11 80	13 60	1 87	25 40	27.31	12	24.35	8											1 035.91		3 140.31	11, 19 & 23	115.00	6	" Uniform Sewerage Statistics "	
Worcester, Mass	128 135	1905	1906 & '07 (Average)	74 94	63 23		138 17	181 40	3 or 4	*12 16	8		47 46	9	58 13	8	4 728 0	2.90			6 894.00	2 137.48	1 608.73	30 031.26	10, 19, 22, 23 & 24	165.65	9	" Uniform Sewerage Statistics "	* 1906 only
IV. Miscellaneous Cities — Data Incomplete.																													
Columbus, Ohio	*125 560	1900										†3.50	1 108 80															Eng. News, Dec. 27, 1900	* Estimated † Large sewer
Hartford, Conn												1.75	623.04	13														Municipal Journal, April, 1908	
Memphis, Tenn	102 000	1900	1902					170.81					4 15	9											16, 19, 22, 23 & 24	51.51	9	Eng. Rec., Feb. 15, 1902	

within a given distance of the street line. The rates of assessment in municipalities which have adopted this method are as follows:

ASSESSMENT.

Municipality.	Frontage per Lin. Ft.	Area per Square Foot to a Depth of			
		100 Ft.	125 Ft.	150 Ft.	180 Ft
Everett, Mass.	$0.50				
Fitchburg, Mass.	0.54 to 0.84				
Harrisburg, Penn.*	0.60				
Haverhill, Mass.	0.20			$0.004	
Lawrence Mass.		$0.0065			
New London, Conn.	0.50	0.007			
Newton, Mass.	0.15				$0.0055
Pawtucket, R. I.	0.25	0.005			
Philadelphia, Penn.†	1.50				
Providence, R. I.	0.60			0.01	
Seattle, Wash.	1.60				
Somerville, Mass.*	0.50	0.005			
Taunton, Mass.	0.20		$0.0024		
Waltham, Mass.	60%			40%	

* Maximum rates.

† With legal deductions of one third longest frontage on corner lots.

In Gardner, Mass., the assessments are levied upon frontage and in part upon use of sewers.

In Laconia, N. H., an assessment of $5 is levied for each connection.

In New Bedford, Mass., one half the cost of lateral sewers is charged to abutters in proportion to the value of land within 100 ft. of street line; on main sewers an assessment of $20 is levied for each connection.

In North Adams, Mass., an assessment of $15 is levied for each single house and $10 for each tenement.

In Plainfield, N. J., the assessment consists of one half the average cost of laying an 8-in. sewer levied on abutters on each side of the street according to the length of frontage.

In Salt Lake City, Utah, and South Bend, Ind., full cost of lateral sewers is charged to the abutters.

In Springfield, Mass., an assessment of $25 is levied for each ground-floor tenement and $1.50 per front foot for business blocks.

DISCUSSION OF MR. HOMBERGER'S PAPER, TRANSLATED FROM BUDAU, "PRESSURE FLUCTUATIONS IN TURBINE PIPE LINES."

Mr. Rolf R. Newman. — Prior to 1903 there had been a great deal of thorough work done on the subject, but it was confined almost wholly to experiments on city water mains. Notable among such experiments were those of Edmund B. Weston,* Prof. Irving P. Church, Prof. R. C. Carpenter of Cornell, Prof. Robert Fletcher of Dartmouth, and Prof. N. Joukovsky of Moscow, Russia.

Of the work since 1903 there should be mentioned a paper entitled "Water Hammer," by O. Simin, which appeared in the Proceedings of the American Water Works Association for 1904. The writer gives a digest of the subject up to 1904, with especial reference to the work of Professor Joukovsky.

Amongst all that has been written on the subject, however, Professor Budau's article is unique in its extended and thorough study of the subject in reference to hydro-electric power plants, and is of great value at this time because it gives prominence to the scientific solution of a matter which even under the best modern practice is only handled empirically.

In 1880 the Risdon Iron Works of San Francisco conducted some elaborate experiments on the subject of water hammer which have never been published, and I have wondered if, through Mr. Homberger or some other member of the Technical Society of the Pacific Coast, these early experiments might not be made available.

Mr. Melvin L. Enger. — In getting a formula for the increase of pressure in a pipe line due to sudden closure of a valve, the author makes two incorrect assumptions: First, that water is incompressible, and second, that the pressure decreases linearly from valve to free end. Water is compressible, and the effect of this factor is too great to be neglected. Experiments at the University of Illinois and elsewhere have shown that the pressure does not become less toward free end when the closure is rapid. For example, in a pipe line 730 ft. long, the full theoretical pressure was developed at a point 30 ft. from the free end, when the closure was very rapid. The same was found by Joukovsky for pipe lines up to 2 500 ft. long. For slower closures quite a reduction occurs near free end.

* Transactions of the American Society of Civil Engineers, Vol. XIV.

The following derivation by Professor Talbot is free from both of the above objections:

"Suddenly arresting the flow of water in a pipe causes the water near the valve to be compressed. Neglecting the distention of the pipe at present, let dx equal the length of a column of water whose cross-section is 1 sq. ft.; let P equal the pressure in pounds per sq. in. generated by the sudden stopping of the water; then the pressure on 1 sq. ft is $144P$. The weight of a column of water of 1 sq. ft. cross-section and dx long is wdx if w equals the weight of 1 cu. ft. of water. Flowing with a velocity v, the energy of this water is

$$\frac{wdx}{2g}v^2$$

"Let λ be the amount the dx length is compressed,

$$\lambda=\frac{Pdx}{E}$$

where E is the modulus of elasticity of water.

"The work done is equal to the average pressure multiplied by the distance moved through. Since the pressure increases from O to $144P$, the average pressure is

$$\frac{144P}{2}.$$

"The work done is equal to the energy in the water

$$\frac{144P}{2}\times\frac{Pdx}{E}=\frac{wdx}{2g}.v^2.$$

Solving,

$$P=\sqrt{\frac{wE}{144g}}\cdot v$$

"Taking $w = 62.5$ lb., $E = 300\,000$ lb. per sq. in. and $g = 32.2$ ft. per sec.,

$$P=63.6v \tag{1}$$

which gives the value for the extra pressure due to water hammer when the pipe walls are considered inelastic.

"Thus if a valve was suddenly closed in a pipe line having a velocity of 5 ft. per sec., the pressure due to water hammer would be $P = 63.6 \times 5 = 318$ lb. per sq. in.

"Considering the elasticity of the metal in the pipe, the deformation of the pipe

$$\lambda_2=\frac{\pi ds}{E'};$$

Also,

$$Pd=2ts$$

where P is the pressure per unit area; d, the diameter of the pipe; t, the thickness of the metal in the pipe; S, the tensile unit stress

in the pipe walls and E^1, the modulus of elasticity of the metal. Then

$$\lambda_2 = \frac{\pi d^2 P}{2tE'}.$$

"The total lateral pressure, F_2, in the pipe is

$$F_2 = \frac{Pd}{2} dx.$$

for a length dx. The work done in expanding the pipe is

$$\tfrac{1}{2} F_2 \lambda_2 = \tfrac{1}{2} \frac{Pd}{2} . dx \frac{\pi d^2 P}{2tE'} = \tfrac{1}{8} \frac{\pi P^2 d^3}{tE'} dx.$$

"The work done in compressing the water is

$$\tfrac{1}{2} F_1 \lambda_1 = \tfrac{1}{2} \frac{\pi d^2}{4} . \frac{P^2}{E} . dx = \tfrac{1}{8} \frac{\pi P^2 d^2}{E} dx.$$

"The energy in the water is

$$\tfrac{1}{2} . \frac{w}{g} . \frac{\pi d^2}{4} . dx . V^2.$$

"Equating energy to work done, and reducing,

$$P = \frac{1}{\sqrt{1 + \frac{Ed}{E't}}} \sqrt{\frac{wE}{g}} V.$$

"Expressing P in pounds per sq. in. and V in ft. per sec., this reduces to

$$= P \frac{1}{\sqrt{1 + \frac{Ed}{E't}}} \sqrt{\frac{wE}{144g}} V \qquad (2)$$

"The form of the equation is the same as the one in which the elasticity of the pipe was omitted. The constant

$$\frac{1}{\sqrt{1 + \frac{Ed}{E't}}}$$

depends upon the size, thickness and material of the pipe."

The velocity of transmission of sound or of shock through free water is about 4 720 ft. per sec. Shock travels through the water in a pipe at a somewhat slower rate, depending upon the material of which the pipe is composed, its diameter and thickness. If γ is the velocity of transmission of shock, it may be shown that

$$\gamma = \frac{4\,720}{\sqrt{1 + \frac{Ed}{E't}}} \text{ ft. per sec.} \qquad (3)$$

γ varies from about 3 000 ft. per sec. for large pipes to 4 400 ft. per sec. for small pipes.

Expressions similar to (1) and (2) have been derived by Joukovsky and Church by other methods. The formulas have been checked by so many experiments that there can be no reasonable doubt as to their accuracy.

In the above derivation it was assumed that the closure was practically instantaneous. Even the quickest closure occupies time. It is, therefore, necessary to inquire a little more fully into just what occurs during the time of closing the valve. When the valve begins to move, a slight retardation, dv, is caused, which causes a slight pressure, kdv. This is transmitted as a pressure wave toward free end with a velocity which can be determined from (3). When the wave reaches the free end it expands and is reflected back as a rarefaction with a pressure of $-kdv$, which also travels with the velocity of sound in the water in the pipe. During the time the wave has gone to open end and back, the valve has closed further, and the velocity of the water has been reduced to v', causing a dynamic pressure,

$$P' = k(v - v').$$

When the rarefaction, $-kdv$, arrives at the valve, it will diminish the pressure to

$$P'' = k(v - v') - kdv.$$

If the valve is closed in a time less than it takes the first pressure wave to travel to open end and back, the full dynamic pressure will be developed.

Solving the author's example on page 138, we find the pressure produced in suddenly stopping the flow of 6 ft. per sec. in a pipe line 54 in. in diameter with $\frac{3}{4}$-in. plates to be 290 lb. per sq. in., or a head of about 670 ft. The author obtains 1 547 ft. for the same case, or about 130 per cent. in excess.

As to the increase in pressure with a known time of closure, it is evident one must know the exact manner in which the water column is retarded. Take as an example a gate valve at the end of a pipe line l ft. long and d in. in diameter, and let H be the difference in head between entrance and lower side of valve. Then if minor losses be omitted,

$$H = f\frac{l}{d}\cdot\frac{v^2}{2g} + m\frac{v^2}{2g}$$

and

$$v = \sqrt{\frac{2gH}{f\frac{l}{d} + m}} \tag{4}$$

in which f is the friction factor and m is a coefficient depending upon the amount valve is closed. Since m is expressed as an

abstract number, it is readily seen that a given closure has less effect on the velocity in a long line of pipe than in a short one.

To illustrate, use $m = 98$ when valve is seven eighths closed, as was found by Weisbach for small valves. Then if $f = 0.02$ and $\frac{l}{d} = 1\,600$, v is found from (4) to be one half of the original velocity when valve was wide open. Making $\frac{l}{d} = 20\,900$ and leaving other values unchanged, v is found from (4) to be nine tenths of original velocity. As a matter of fact, the velocity will be more than this on account of the dynamic pressure caused by closing the valve. In the last case, if the last 12 per cent. of the closure is made in a time less than the time required for the shock to travel to free end and back, 90 per cent. of the maximum water hammer will be caused.

There are so many factors entering into a determination of the maximum pressure caused by a closure slower than the time of round trip of pressure wave, and the effect of small variations from assumed law of closing is so great that no simple formula could be expected to give even approximate results.

The writer cannot agree that a standpipe is always superior to an air chamber as a means of regulating the flow. When the standpipe becomes very long or high, the inertia of the long water column makes it inefficient in taking care of minor fluctuations of pressure. The failure of the air chamber has been due to the ridiculously small sizes which have been tried. If anything like the amount of metal was put into an air chamber that is sometimes put into a standpipe, and the chamber kept supplied with air, good results would probably be obtained.

OBITUARY.

Elbridge H. Beckler.

HONORARY MEMBER, MONTANA SOCIETY OF ENGINEERS.

ELBRIDGE H. BECKLER was born in Boston, Mass., October 16, 1854, and moved with his parents at an early age to Livermore Center, Me. After obtaining an elementary training in the public schools of that town, he took a preparatory college course in the Wesleyan Seminary at Kents Hill, and, after graduation with high honors, he joined the class of 1876, in its junior year, of Maine State College at Orono, from which he graduated in 1876 with the degree of civil engineer. The following year he went to Minnesota seeking professional work in the line of railway construction, but finding no situation open to him, he devoted the next two years to farming, teaching and general surveying. In 1879 he secured the positions of transitman and assistant engineer for the St. Paul, Minneapolis & Manitoba Railroad, at Fergus Falls, Minn. After working for this company one year, he secured employment as locating engineer with the Northern Pacific Railway and had the supervision of the location of that road from Glendive, Mont., to Helena, Mont., a distance of several hundred miles. When he had completed this part of his location work, he took charge of some very heavy construction work as well as the big tunnel at Bozeman Pass, at that time one of the longest tunnels in Montana. He continued in the employ of the Northern Pacific Railway six years, except a few months in 1884, when he acted as locating engineer for the Canadian Pacific Railway west of the Rocky Mountains, along the Kicking Horse River. In addition to his other duties while employed by the Northern Pacific Railway he had charge of the construction of a bridge across St. Louis Bay, for the entrance of the Northern Pacific into Duluth, Minn.

When the Great Northern Railway Company undertook the extension of its line to the coast, Mr. Beckler became its engineer of location, a class of work in which he particularly excelled. In 1889 he was made chief engineer and had charge of the construction of the whole line from its junction with the Montana Central Railway to Puget Sound. This work he completed in 1892 and the next year he went to Chicago to reside and follow his

profession, chiefly as consulting engineer. In 1896 he entered the employ of Winston Brothers, and at length became a director in Winston Brothers Company. When the extension work of the Chicago, Milwaukee & St. Paul Railway to the coast was prosecuted his company held several contracts from that road to which he gave his personal attention. In his charge in particular was the long tunnel through the Bitter Root Mountains, recently completed, which is a lasting monument to the engineering skill and excellent judgment of Mr. Beckler and his associates. Mr. Beckler was suddenly stricken in August last by a fatal illness, and left a widow and two daughters, residents of Chicago. He was an active member in several engineering societies, a charter member and one of the first presidents of the Montana Society of Engineers, and at the time of his decease one of the three of its honorary members.

Mr. Beckler was a person of high ideals, of rare executive ability, of enduring patience, of brilliant mind, of daring courage, of steadfast devotion to his profession and employers. He made a place of lasting fame for himself in the great pioneer railroad enterprises of the West and in all his professional career "he was the man behind the gun."

Rutger Bleecker Green.*

MEMBER DETROIT ENGINEERING SOCIETY.
DIED DECEMBER 8, 1908.

RUTGER BLEECKER GREEN was born at Syracuse, N. Y., October 8, 1868, and was the second son of Andrew Heatley Green, a prominent attorney of that city, and Mary Miller Green. He prepared for Cornell University in the public schools of Syracuse, N. Y., and Morristown, N. J., and entered Cornell in 1890. He was graduated with the class of 1895, one year having been lost because of sickness. As an expression of their appreciation of his ability, and of their regard for him, during his senior year his classmates bestowed upon him the highest honor within their power by electing him chief engineer of the survey made by the senior and junior classes at the northern end of Owasco Lake, New York.

Previous to entering college he had had considerable practical experience, having been engaged as chainman on the New York State Canals from September, 1887, to June, 1888;

* Memoir prepared by M. S. MacDiarmid, member Detroit Engineering Society.

chainman and instrumentman on the Richmond & Danville Railroad from September, 1888, to June, 1890; chainman on the Adirondack & St. Lawrence Railroad from April to September, 1891. From April to November, 1893, he was assistant engineer on the construction of the Syracuse water-works pipe line from Skaneateles Lake, and was in charge of cross-section and construction survey party sections 1 and 3.

After graduation, Mr. Green was an assistant on the editorial staff of the *Engineering Record* from November, 1895, to October, 1897; and from November, 1897, to April, 1898, he was a leveler on the New York State Canals. In November, 1898, he accepted a position as civil engineer with the Detroit works of the Solvay Process Company, and had charge of the land surveys of the 400-acre plant on the Detroit River, designed and constructed yard system of 8 miles of tracks, with 75 turnouts and 8-stall locomotive house, 1 mile of concrete sewers, 2 miles of gas and water pipe for manufacturing and fire protection, including yard system of 40 hydrants and automatic sprinkler systems. He also supervised the construction of the foundations and superstructure of 300-ft. railroad drawbridge and coal-car tipple, and the enlargement of foundations of 260-ft. chimney; also foundations of various office and factory buildings, including lime kilns, dynamo house, ammonia tanks, concrete bulk-soda storehouse and office building.

Personally Mr. Green's disposition was particularly loving and sympathetic, and all with whom he came in contact were pleased to call him friend.

Special mention should be made of his interest in religious and philanthropic affairs, as at the time of his death he was treasurer of St. Mark's Episcopal Church at Delray and a trustee of D'Arcambal Home.

Too close application to his work, and the intense interest which he took in everything in which he engaged, resulted in a nervous breakdown, and in June, 1907, he took a trip to Europe for his health, but was not permanently benefited.

A recurrence of the old trouble during the past summer and fall caused such a state of mental depression that, with the words, "I am worked out," he sought rest in death, December 8, 1908.

Mr. Green was elected a member of the Detroit Engineering Society October 26, 1900, and was made a member of the American Society of Civil Engineers September 6, 1904, and had contributed valuable papers to each society.

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SOME ANOMALIES IN MODERN PLUMBING REGULATIONS.

BY J. PICKERING PUTNAM.

[Read before the Sanitary Section of the Boston Society of Civil Engineers, December 2, 1908.]

I THINK good plumbing might be defined as a convenient arrangement of well-flushed fixtures securely trapped and drained.

To be *convenient*, it must be of such a kind that it can be installed at a reasonable cost wherever convenience dictates, and, once installed, easily understood, as in case of accident, by the owner. To secure this the utmost possible simplicity is a prime necessity.

Adequate *flushing* is absolutely necessary to maintain the plant in proper working order.

Secure trapping implies a water seal which can be permanently relied upon as a barrier against the entrance of sewer air under every possible adverse influence occurring in plumbing, such as siphonage, back pressure, evaporation and sediment accumulation.

Finally, *security in the drain piping* implies a method of jointing which can be permanently relied upon to be air- and water-tight. This again implies sufficient flexibility of jointing to accommodate itself to the unavoidable shocks, settlements and shrinkages always encountered to a greater or less extent in building sites and materials.

The Boston plumbing law of this year is deficient in every one of these particulars, although it is a great improvement on

the requirements of previous years, back venting and main house trapping no longer being obligatory. Nevertheless, back venting is by the wording of the law recommended, and the use of the simpler and more reliable antisiphon trap system is only allowed on the approval of the commissioner. This is very bad, because it throws the onus of the decision upon an individual already sufficiently overburdened with work and responsibility, of important matters which could easily and should evidently be decided once for all by proper scientific authorities or by impartial expert bodies commissioned to study the data, amply sufficient to-day to warrant such decision.

It is possible for any one to-day having the proper apparatus to demonstrate easily whether or not a water seal is better protected by the back venting or by the antisiphon trap system; whether or not the main house trap does more good or more harm; and whether the lead-calked joint for cast-iron pipes, now specified as the only one allowed, is really a reliable joint or whether it is the most unreliable and unscientific form of construction in the whole domain of modern building; and finally whether or not a permanently reliable pipe joint can be made which will be sufficiently flexible to stand without injury the shocks and movements in streets and buildings due to settlements and shrinkage of materials and to the transportation and deposit of heavy bodies in their neighborhood.

All these questions are now subject to such complete and easy demonstration to-day that the uncertainty and mystery surrounding them in the mind of the public is quite inexplicable, except through a recognition of the fact that private interest finds its advantage in such ignorance. Pipe dealers are financially interested in maintaining the elaborate system of piping and trapping required by back venting and main house trap installation. Plumbers, on the other hand, have nothing to gain by it, but rather much to lose, since what money goes into unnecessary piping is lost for better fixtures and more of them, and the public, alarmed by all the complication, becomes distrustful of all plumbing and tries to do away with its benefits as far as possible. Leading plumbers are, therefore, strongly urging these simpler and better methods.

I shall endeavor to show to-night the manner in which these demonstrations may be made without great cost by any one desiring to see our plumbing laws improved and his client's as well as his own interests safeguarded.

Figs. 1 and 2 show a form of apparatus upon which a standard test may be made by any board of health or plumbing inspector to demonstrate absolutely the far greater efficiency

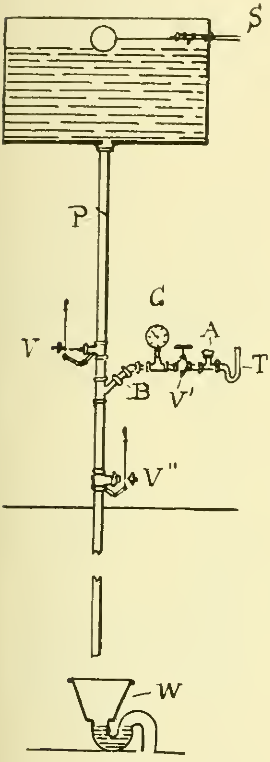


Fig. 1.

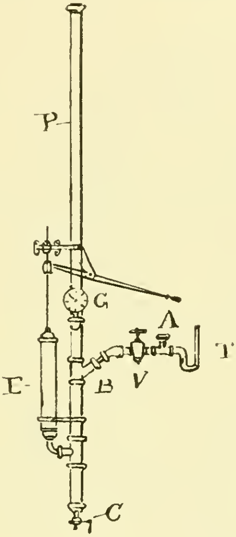


Fig 2.

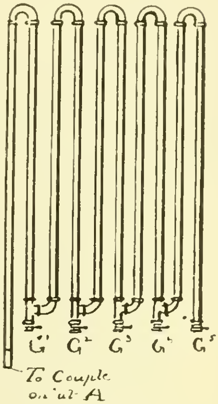


Fig. 3.

of the simpler antisiphon trap system of water seal protection than of the complicated back vent pipe method.

You see two forms of the apparatus side by side: the first, "hydraulic," requiring a water tank and water supply as well as a waste receptacle; the second, "pneumatic," requiring only an air exhaust pump. In both, 2-in. waste pipes are used with branch wastes to hold the traps to be tested, and quick opening gate valves and vacuum gages to measure the force of the siphoning action applied. An outlet opening just back of the trap is provided for connecting up a system of back air pipes shown in Fig. 3. These two forms of apparatus give exactly similar results, and both forms are useful in an inspector's office for checking one another. In the hydraulic apparatus the size of the tank is governed by the size of the water supply

pipe and the amount of water pressure available. It should be sufficiently large to supply water enough for a standard number, say ten, successive strains on the water seal of a trap without refilling.

The pneumatic apparatus permits of wider and more accurate comparative tests on the absolute and relative efficiency of different kinds of traps or systems of trapping.

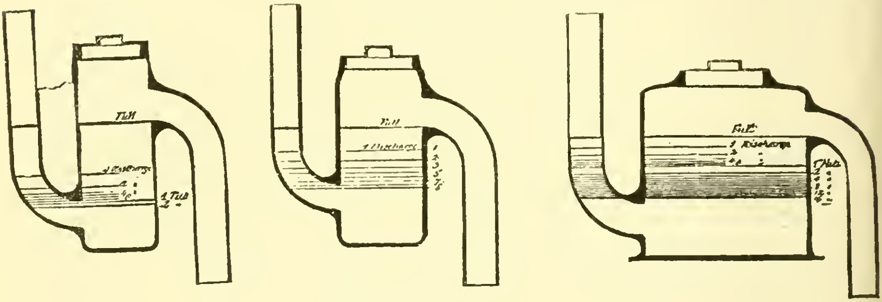


FIG. 4.

Fig. 4 gives a record of tests made by the hydraulic apparatus on different kinds of traps tested for resistance to siphoning action. The same strains are brought to bear upon each of the traps in succession, and you will observe by the horizontal lines the effect of each strain on the trap seals. Identical results are obtained on the pneumatic apparatus when the same degree of strain is applied as indicated by the vacuum gage.

Now, we have made hundreds of tests at various times and places, in private and in public, with a great variety of testing apparatus, and very often on stacks of pipes and with traps installed for actual use in plumbing work, and invariably with the result that the unvented antisiphon trap always shows a resistance immeasurably superior to any vented siphon trap. Indeed, a properly constructed antisiphon trap is absolutely unsiphonable, while the vented S-trap, favored by the law, has little comparative strength of resistance and easily loses its seal even in ordinary plumbing practice and when the back vent pipe is new and clean. When the vent pipe is partially or completely closed by grease, sediment or frost, as very often happens, it loses what little power of resistance it may have originally possessed and becomes nothing more than a snare and a deception, providing only a false sense of security. The clogging of an antisiphon trap of proper

construction simply reduces the rapidity of waste outflow without reducing its resistance to siphonage.

It will be observed on the drawings that the ordinary pot trap is capable of resisting siphonage if sufficiently large, and the greater its diameter the greater its power of resistance. I have used various forms of testing plants in these demonstrations. The same apparatus serves also to show the rela-

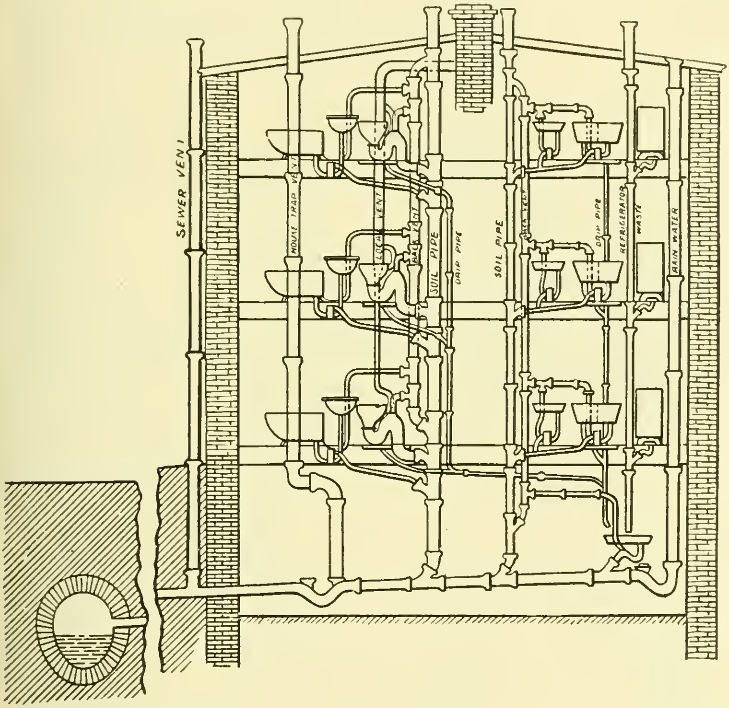


FIG. 5.

tive efficiency of antisiphon traps and back-vented traps in withstanding loss of seal by evaporation, and the tests show, as might be expected, that the air current produced by back venting destroys the water seal with a speed proportionate to its efficiency as a ventilator, and we see that this destruction of the seal by evaporation proves to be a danger far more important than any useful service it could possibly perform under the most favorable conditions. So often and so conclusively and satisfactorily has this been demonstrated that it has become accepted as a perfectly established fact among sanitarians

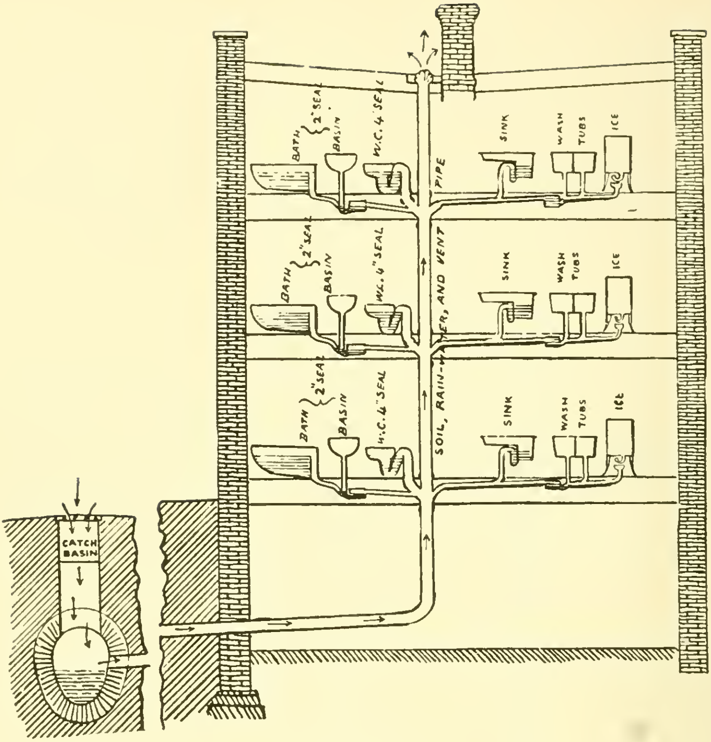

BATH
2" SEAL
BASIN
W.C. 4" SEAL
SINK
WASH TUBS
ICE
SOIL, RAIN-WATER, AND VENT PIPE
CATCH BASIN

FIG. 6.

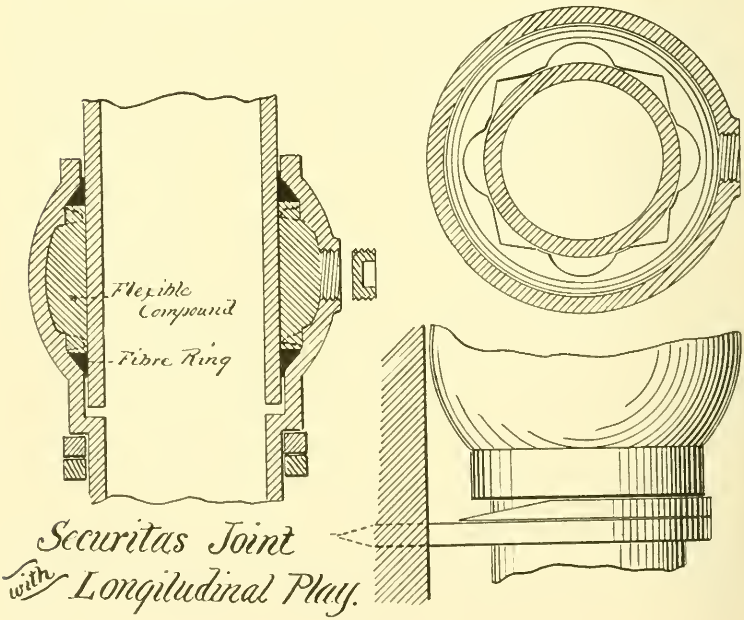
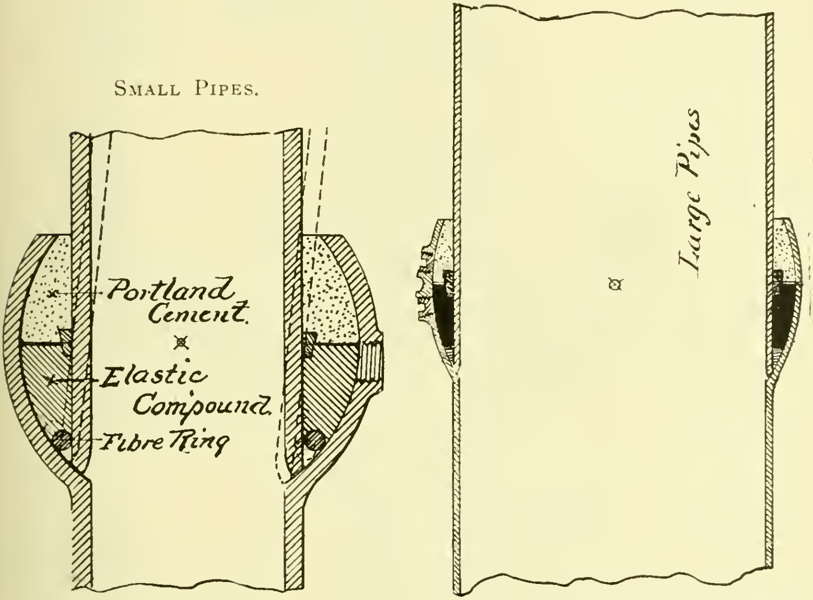

Flexible Compound
Fibre Ring
Securitas Joint
with Longitudinal Play.

FIG. 7.

about which there is no question whatever, and it only now remains for boards of health to make the same tests, to come to the same conclusion and revise the building laws accordingly.

Fig. 5 and 6 show the two systems of plumbing we have been considering — the first the complicated and the second the simple one. When we consider that in the latter the method adopted of pipe jointing is very much less expensive, while it is both reliable and flexible, we see that the cost of plumbing



"Securitas" Joint. Form providing for Rotary Play.

Fig. 8.

may easily be cut in two, the saving in repair work being much more than half the total expense, and in new work nearly half.

Figs. 7 and 8 give sections of the flexible joint I refer to which I have called the "Securitas" joint. It is composed of a permanently elastic compound unaffected by cold or heat up to nearly the boiling point of water, inserted as shown in Fig. 9. It permits of an amount of perpendicular play of one pipe in another equivalent to the maximum amount of contraction and expansion in the pipe system, and a simpler modification of detail shown in the drawings admits, in the fittings, of a rotary motion to take up any shrinkage or settlement in the building. I have not time this evening to explain the

construction of this joint in detail. It must suffice to say that after three years' testing under a water pressure of 45 lb. the joint has remained perfectly tight even though the pipes forming it were moved by longitudinal and by rotary motion several times a year during the tests, and during this time also

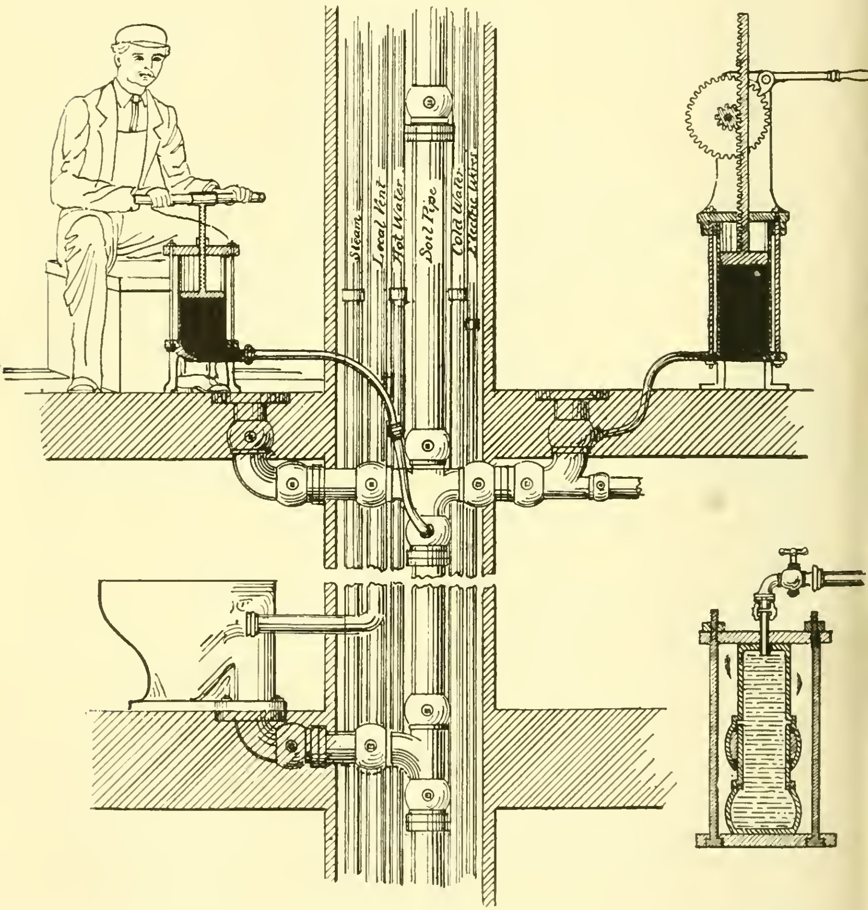


FIG. 9.

they were alternately subjected to freezing cold and almost boiling hot temperatures. The making up as shown in the picture can be done after the pipes are once in place in twenty seconds, while the hand calking of a lead bell and spigot joint requires as many minutes.

I have said that the siphonage-resisting power of an ordinary unvented pot trap is far greater than that of any vented siphon

trap, and that its power of resistance was in proportion to its diameter. It is also quite independent of its height or of the depth of its seal. Fig. 10 shows some very wide and shallow sealed traps which are absolutely unsiphonable. They consist of a very shallow return bend entering the bottom of a

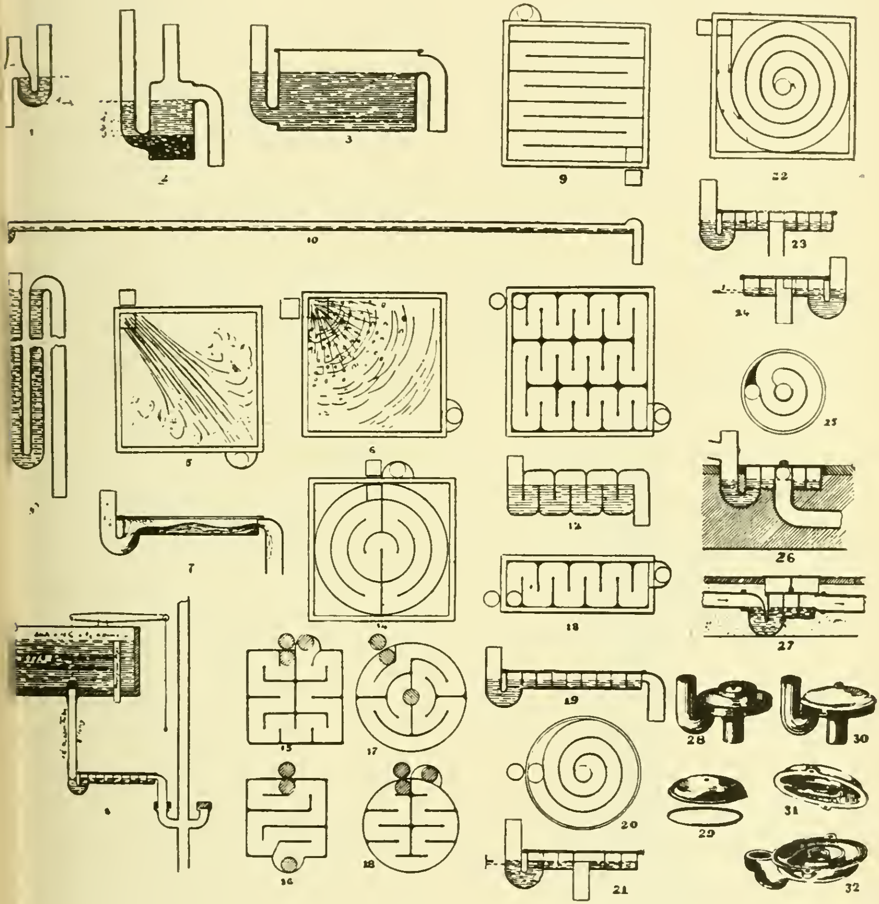


Fig. 10.

reservoir chamber of height substantially equal to the diameter of the waste pipe and so subdivided by partitions as to form a continuous waterway from inlet bend to outlet arm. This water way has a sectional area equal to that of the waste pipe, so that in normal use it shall scour itself when used with a properly constructed fixture having an outlet large enough to fill its waste pipe full bore. Even the smallest size of these

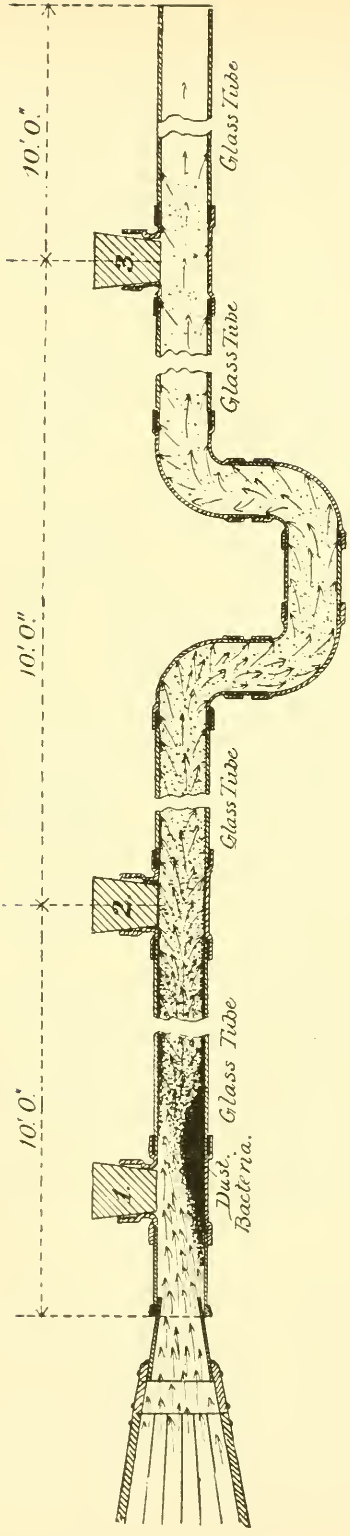


Fig. 11.

traps is absolutely antisiphonic in plumbing. Hence it provides the desideratum long sought for in plumbing of a combination of the simple self-scouring form of the siphon or S-trap with the antisiphon quality of the largest pot or cesspool traps, and it has the peculiarity of retaining its antisiphon quality even when partially clogged with sediment, as under sinks or other fixtures improperly constructed as to flushing outlet. It can, therefore, never lose its seal, because when fully clogged the refusal of the waste water to escape announces its condition and compels the removal of the obstruction. I have called this trap the "Securitas" trap.

There are, however, many other forms of antisiphon traps, including the ordinary large pot trap, which are practically antisiphon, and all are vastly superior to the expensive back-vent system. The public are, therefore, not dependent upon the use of any special or proprietary article for their protection.

Fig. 11 shows the apparatus used in my own experiments to discover whether dust and germs can escape from sewage on the damp sides of sewers and house drain pipes when once they have fallen therein. None of the particles could be forced clear through the tubing even by powerful blasts of the bellows. The wet sides arrested them as shown.

My conclusions from my own experiments and those of eminent investigators like Carmichael, Miquel, Frankland, Naegeli, Carnelley and Haldane, Laws and Andrewes, Alessi, Pumpelli and Smyth, Major Horrocks, and, latest of all, Prof. C.-E. A. Winslow, of Massachusetts, may be summarized as follows:

(1) A sound water seal affords a reliable barrier against the entrance of sewer air and all kinds of germs.

(2) Dust and germs falling into water or against the wet surfaces of sewers and drain pipes are, under normal conditions in the drains, arrested and prevented from rising again into the air so long as the surfaces remain wet.

(3) Abnormal conditions prevail in drains when splashing or bubbling occurs in the sewage, under the influence of which fine droplets may be projected into the surrounding air. If these droplets contain germs and are minute enough to be wafted in the air currents passing through the pipes the germs therein may remain in the air until they again fall against the wet surfaces. Even germs have a definite weight, and the speed of their descent under the influence of gravity has been calculated, and these calculations give also the speed of an air current necessary to support or move them.

(4) It is possible that small particles of sewage which have dried against the upper parts of the walls of the sewers may be detached therefrom by air currents and in this manner allow of the escape of germs into the sewer air. The probability of this action is denied by some investigators but affirmed by others. It may be admitted as a possibility.

(5) Disease germs seem to be unable to survive long in sewage, the non-pathogenic germs therein far outnumbering them and destroying them by their products.

(6) Fewer germs are found in the air of sewers than in the outer air above the sewers, and those which are found in the sewer air are dissimilar in kind from those in the sewage, but similar to those in the outer air.

(7) The number of germs present in the air of well-ventilated sewers exceeds that in less well-ventilated sewers and varies with variations in the content of the street air, implying that their origin is from without and not from within the sewer.

(8) The majority of investigators have failed to isolate specific disease germs from the air of sewers, and it may be stated in general terms that they are not to be found there under normal conditions. Yet a few well-known investigators have

obtained cultures in the air of sewers of germs apparently coming from the sewage under conditions apparently normal, and it is generally admitted that the splashing, bubbling or drying of the sewage may release them under rare conditions in good practice. *Their numbers in sewer air must, however, in properly constructed sewers, be so small in the whole volume of the sewer air that their effect regarded from a sanitary standpoint may be considered as negligible.*

(9) It is known that disease germs, especially those of consumption, may be disseminated in the air above the sewers, and may, especially in times of epidemic, abound therein in large numbers and unquestionably in larger numbers than in the air of the sewers themselves.

(10) Under such circumstances street air passing through the sewers and house drains becomes filtered by them and emerges from the pipes freer from its dust and germs than when it entered, and must, in fact, before reaching the tops of the stacks above the roof be entirely freed therefrom.

(11) Currents of air rising through the soil pipes in buildings act like smoke in chimney stacks, taking a spiral course as it ascends. In so doing, as well as in passing around bends and angles, every particle of air tends to strike against the inner surfaces of the pipes more or less often before reaching the roof. The result of this phenomenon is that any dust and germs which might enter the house drainage system from the public sewer are bound to be arrested somewhere along the wet surfaces of these pipes and be ultimately destroyed. Hence, with good plumbing, the possibility of the entrance of a disease germ into the house from plumbing pipes becomes practically nil. If there is any danger whatever of contracting disease from the air in the sewer itself so ventilated, all such danger is thus eliminated for residents in the houses connected therewith. More questionable germs are consumed every twenty-four hours in ordinary food and drink, or inhaled from the outer air, than would probably be obtained from the soil pipe air in a lifetime.

(12) The omission of the main house trap converts every house drain into a sewer vent and insures the destruction of any dust and germs, pathogenic or otherwise, which may under normal or abnormal conditions be found in the sewer. The rate of purification of the air of cities by this method of filtering it through the sewers and house drains is very great, amounting, by my calculations, to over a million and a half cubic feet per

minute for every square mile of the city's area, or to the ventilation produced by a ventilating chimney 68 ft. in diameter conducting air at a speed of 419 ft. a minute.

(13) The use of the main house trap obstructs sewer ventilation and results in forcing any pathogenic germs and foul and dangerous odors it may contain into the street through the sewer gratings.

(14) The use of the "back-air" pipe with traps tends to destroy their water seal by evaporation, where unvented antisiphon traps are capable of retaining their seals under all conditions encountered in plumbing practice, and for many months without refilling.

(15) Drain piping may now be installed in such a manner as to be permanently sound and reliable.

(16) Splashing in sewers may be avoided by a proper construction of the pipe connections with the sewer.

(17) Whatever danger, if any, there may be from the possible presence in rare and isolated cases of disease germs in the air of the sewer itself, that danger may be practically eliminated by ventilating the sewer through the house drains and using sound plumbing and unvented antisiphon traps. Under such conditions there is indeed a possible danger of contracting disease from dust and germs coming in through open windows, but none from the plumbing system, because the former may and the latter cannot transmit the germs.

(18) The shallower the seal of an antisiphon trap the better. It not only requires less water to refill it from its reservoir or "refill" chamber after siphonage, but it will then protect the seal of any adjoining water-closet trap as well as itself.

DISCUSSION.

Mr. Craig.*— I am pleased to be with you to-night. The letter sent me by your clerk called upon me to speak in regard to plumbing conditions of to-day, and I suppose I had better confine myself to that. Mr. Putnam's lecture has been very entertaining, and though, of course, there is room for a good deal of discussion on some of the points he has raised, I don't think it advisable at this time to go into them to any great extent. I will say in passing that he has the law a little bit strained, because you can put in a system of modified trap vents under the present law; the law is not very well understood. We have only been working under it for about a year, and there

*President Master Plumbers Association.

are modifications that have not been taken advantage of at all. In regard to trap testing, I have been doing that same work for the last ten years myself in connection with the North End school on the apparatus shown in one of Mr. Putnam's slides, and, as a matter of fact, it has been part of the work of our National Association for the last two years to determine what was dangerous to health in sewer air. Our association has spent $1 500 up to date, and will spend probably as much more to print a report of the investigation. After January, when we have our directors' meeting, we shall probably go ahead with the preparation of that report. Professor Winslow, who was supposed to speak here to-night, would probably have spoken about how dangerous this sewer air is as a germ-carrying medium. He not being here, I would say that I was appointed chairman of the sanitary committee of the National Plumbers' Association, which is one of its standing committees. The association thought at that time that the subject of sewer air was a branch of the science of plumbing which should receive some attention from them as an association. They decided that there was no better place to take up the consideration of that subject than in Massachusetts, and they wanted a Boston man appointed, so they made the speaker chairman of the committee which was to conduct the investigation. I took up the work with the Institute of Technology, and I must say that Professor Sedgwick and his confrères who have made the experiments have been exceedingly kind in everything that looked toward the forwarding of this work. I simply speak of these studies to show you what the plumber has been doing towards setting himself right before the public. Believe me, this is largely the thought of earnest members of our association throughout the whole country. It is their earnest desire to stand right. The plumber was not the father of this back-vent law in its inception. The plumber does not know to-day how to determine whether this is a means of disease carriage or not. That is all a matter for the scientific investigator. It is not the business of the plumber How would a plumber determine that in practice? Even the best of us, who try to keep in touch with the most advanced conclusions of bacteriology, cannot be expected to determine these things which belong specifically to the laboratory. I am going to defend the plumber only so far as this: If he didn't know, he took the next best course that was open to him, and that was to be sure. We must not forget that sewer gas is

poisonous, irrespective of its inability to carry disease germs. It is not a good thing to have as a steady diet. We are all aware of that. Consequently, we are inclined to be guarded in what we do in the matter of this connection. In the meantime we have gone hysterically in this matter of plumbing legislation. Everybody who had anything to say about the mysterious qualities of pipes and plumbing had his ideas worked into the laws, the plumber naturally going with the public. Now, aside from the question as to whether a mechanical trade should have law — and that is a very broad question — I am in doubt, and some of you folks are in doubt, as to whether legislation should apply to us as a craft,— and that is what we are, craftsmen, not professional men, — and we should have been left to pursue our calling in a simple manner. To be wise under those conditions is pretty hard. To come out with safety may be still harder. Now we are on the road back. We will go with you or the public so far as we think it is safe. The intercepting trap is a moot point in certain sections of the city where steam is allowed to escape into the sewers of the city. Mr. Putnam will say it must not escape, but it does.

Mr. Putnam. — Oh, no; I don't say that.

Mr. Craig. — I am using you as a figure, if you please. It will be said that steam must not escape, yet the fact remains that it does escape, and we have got to deal with that condition. During the time of my investigation I was called upon to remove a trap for the Transit Commission, made obligatory by some of their demands, and there were at least three inches of steam pressure, and the lead in the trap joint was driven out. If it had not been for that trap every joint in the house would have been in the same condition.

Mr. Putnam. — What joint?

Mr. Craig. — The joint at the running trap, the intercepting trap. Now, we are crude in this matter of jointing, very crude, indeed, and I admit that Mr. Putnam is skillful in getting away from the lead joint. Other methods are better. People who have made special studies of sewer air and sewer conditions were the ones who were responsible for the hysteria about sewer air in the beginning. It was not the plumber. He did not know about those things but accepted the word of those who ought to know. Now we are traveling back and we want to go carefully. Witness the expense to which our national association has gone to determine if possible just what we shall do and just where we shall go. The passing of codes, the building

up of fabrics of law in regard to a simple craft like ours is wrong. When the last word is said, it means that the code obliterates the personal equation altogether. Nationalism obliterates ambition, or at least nullifies it, and in the same manner codes for the mechanic take away his skill. That is the history of it. When we make laws governing the skill a man might employ in erecting anything, if that law obtains and is part of the administration of his daily life, his skill goes with it. The result is that you want trade schools, and want them more and more.

Now, with those conditions, the plumber is standing in a place where he says that he will want to know before taking the next step, and the next step beyond that he will want to know, and he will go on in that way and in that way only. At the present time there is a committee, consisting of representatives of the Real Estate Exchange, the Civic League, the Society of Architects and the Master Plumbers, and, I think, one other society, which meets each week to discuss modifications in the present law. It has been told me by those who are in a position to know that it is very rarely that a law is passed which is workable without one or two years of amending afterward. This is the first year. We don't want as a body of men to pose before the public as we have been forced to do as extortioners or as self-seekers who trade on the public fear. Not at all. It is not the plumber's desire to do anything of that kind. I think, in saying that, I voice the opinion of the great body of my confrères. We are just as proud and just as ambitious to pass on to our children the fact that their fathers were in an honorable calling as you are. We have the pride of calling and we have the pride of place, be it ever so humble. It is there as surely as it is anywhere. We are willing to go any distance to approve the proper conditions for plumbing. In the meantime the great extensive bulwark of administration has grown around this matter of plumbing. Now from the very conditions created by the law you will find it difficult to amend your plumbing law. Those conditions crystallized the administrators themselves into organizations that are a power just as much as you are and as we are. So this thing is not as simple as it might appear at first flush.

Now, in a practical way, as to plumbing conditions as practiced to-day by our craft. In the city of Boston I don't know but what we have as simple a form as we might have,

apart from the trap as criticised by Mr. Putnam. I find that the maker of the trap — and this is a very essential thing — the maker of the trap knows just what to charge to stand between you and the loss of that air pipe. That is done. That is a fact. The omission of a piece of pipe running over there from a bowl that might set in that corner to the main vent pipe — the omission of that pipe, I say, is exactly balanced by the price of the trap.

Mr. Putnam. — That is not so — not when patent traps are used.

Mr. Craig. — We have to use patent traps. We have to do it. I beg to differ from you.

Mr. Putnam. — Explain why.

Mr. Craig. — The department says only this is allowable.

Mr. Putnam. — That is what we all test for.

Mr. Craig. — Coming to the pot trap. We have made a number of tests each year, and two years ago we tested expressly for the National Association of Plumbers and we found that the special trap of Mr. Putnam's is unbreakable. But here we have a pot trap with inlet and outlet set at right angles. In every one of Mr. Putnam's illustrations you will notice that the inlet came in on one side and the outlet went out opposite to it, so that in reality it is simply a bulb of water around an S-trap. We found that where the inlet came in on one side below and the outlet went out at right angles above it it was almost impossible to siphon the trap. If you will note, the best and clearest definition of that was given to me by Mr. Frederic I. Tudor, who said you want the water to roll away and the air to go by it. In this case the water is thrown up. The air strikes it and the impact drives it over to one side and the air goes up and passes by. That is a strong form of pot trap and one frequently used. But you can't write it into an ordinance.

Last year we believed that the man with a large venture down town for office buildings would be allowed to waste five or six water-closets without any trap vent, returning only into a general vent line. And that was allowed. And to put the three-flat houses on the same basis we had this done: The top fixtures of the house within 5 ft. of the soil pipe are not vented. All the top fixtures within 5 ft. of the soil pipe are not vented. No matter whether they be three, five or ten, if they are within 5 ft. of the soil pipe you can leave off the vent pipes because the pipe going through the roof answers. We said, if that is

allowed on the top floor, why not place the second floor on the same basis by a vent line. And that was done. And it was carried to the first floor, where there was a similar arrangement, and that vent line, with the branches arranged in the center, obliterates all the small trap vents. That is allowable under the present law. Of course, as I said in the beginning, there are many things permissible under the present law of which the general public is not aware. But that was done at the suggestion of the master plumber. And thus we try to go along and better the conditions as we find them. The future does not look so bad but that we can get something better with all our efforts, something vastly better than it has been, at all events.

Mr. Putnam. — Mr. Craig's objection that the omission of the main house trap would at times allow steam to enter buildings and open the joints seems to me to have little weight to offset the heavy advantages of its omission, because the common lead-calked pipe joints used in houses to-day have already been so badly shaken up by the almost boiling hot water admitted to them in ordinary use, compressing the lead, which never expands again, that the rare admission of steam could hardly make matters worse. Nearly all such joints are already unsound, as the application of a pressure test generally shows. The joints have become *dirt* joints, but no longer lead joints. Moreover, settlement and shrinkage in the building materials are always at work on such rigid joints, which can only yield to pressure without cracking by opening the lead, and were it not that the warmth of the house and of the sewage and the admission of this very hot water and occasional steam usually created an inward current from the house into the soil pipe, instead of an outward current, we should hear more from these poor joints than we do now.

With sewers ventilated, however, at every house drain, there would be no such thing as foul sewer gas to trouble the house owners in any case. Not only would the sewers be ideally ventilated, but the dust and germs in the outer air of the city would be filtered at the rate of 1 500 000 cu. ft. per minute per square mile of city and at a saving of a half a million dollars per square mile of city in plumbing bills besides. To install all these traps at this enormous expense and at the sacrifice of the immense advantage in sewer ventilation we have pointed out, because of a fancied injury which the last few degrees of heat between boiling water and steam vapor would produce on an unscientific and foolish form of rigid pipe joint

already distorted by building settlements and shrinkages, savors too much of straining at a gnat and swallowing a camel. If steam must be taken care of, there are several ways of providing against trouble from it better than the installation of main house traps, one being to condense the steam before entering the drainage system; another to carry up a special steam vent-pipe, and another to use a form of jointing unaffected by steam. Back venting and main house traps should be rigidly prohibited by law. Until this is done at least as rigid a standard test should be required to insure efficiency on the part of the back-vent system when allowed as is now required of antisiphon traps.

Chairman Johnson. — We have with us to-night a representative of a third class, the ones responsible for all this, the health officials. I take pleasure in introducing Mr. Coffey, the chief sanitary officer of Worcester.

Mr. Coffey. — I don't know that I can add anything to the sum total of the knowledge of this gathering, or say anything that will be of interest. I confess that I watched Mr. Putnam's slides and listened to his explanations with a great deal of amazement. His ideas seem to me, from my knowledge of the plumbing business, to be rather revolutionary. I know as a health officer that of late years sanitarians are becoming more and more impressed with the knowledge that filth *per se* has very little to do with the spread of contagious diseases. We are beginning, of course, more and more to come to the conclusion that contagious disease is spread more by direct contact than by any other agency. But — there is a but in the subject as yet — we are not fully convinced that that is absolutely true. And we are in a state of uncertainty regarding this plumbing question for instance.

It is true, as Mr. Craig said, — and I listened with a great deal of interest to what he said, — it is true that plumbers are not to blame for the condition of things, these fixtures and this aimless venting. The plumber simply did what he was forced to do by law, either by ordinance or by statute. And if those things Mr. Putnam has said here to-night are true, it seems to me that the subject is of sufficient importance, not only on account of the amount of money involved all over the state of Massachusetts every year in the introduction of these vent pipes and these traps, but also on account of its effect on the public health, to demand serious attention on the part of men qualified to deal with it and arrive at a practical solution. I

think it would be an excellent thing if some body of men in the state, some body like the Society of Civil Engineers or the Association of Boards of Health, would see that a series of tests were made that would settle these questions; because, as we are seeing here to-night, when the practical man on the one side and the theoretical man on the other side disagree, who shall decide?

Now, if this matter is capable of being standardized and correct results obtained from it, it seems to me that the subject is of importance enough for somebody to see that those things are done, in order that we may stop the waste of money and the waste of time and thought that we are now lavishing on the plumbing of our houses.

I was asked in the letter of invitation to speak to-night more particularly of the house trap, so called. In Worcester, until the ordinance we are now working under was passed in 1895, the house trap was not required in our plumbing ordinance. But when the ordinance of 1895 was adopted, that was included. And since then it has been the rule to insist on the house trap with the foot vent. Now, I know there are things to be said on both sides of this question. The object of the trap originally was to put a gate between the household and the outside influences which are believed to be dangerous. Later knowledge, and, perhaps, better knowledge, has shown that that danger was exaggerated, and we are now under belief which is rapidly becoming universal, as I said before, that the danger from sewer air and from filth *per se* is not nearly so great as it was then thought to be.

But are we entirely free from danger from this sewer air? It is true, probably, as Professor Winslow has demonstrated, that sewer air in itself is not very largely impregnated with pathogenic organisms. But is it true that there are not certain individuals who may be susceptible to the injurious effects of sewer air? Or, rather, is it right that we should not take into consideration those individuals who are liable to injury by the breathing of sewer air? We know, of course, that certain people have a certain susceptibility to disease, that certain people are highly sensitive, that the old saw which says that one man's meat is another man's poison has a great deal of truth in it. And this sewer air that the laborer who is employed in the sewer seems to be able to breath without any ill effects — isn't it a fact that while that may be true, the highly sensitive child or woman or man, who may be living in a house in which this

sewer air is allowed to enter, may be injuriously affected by the breathing of it, even though it might carry with it none of the pathogenic germs that are so much dreaded?

One object of that house trap, as Mr. Craig pointed out, is to keep out the steam that is allowed to enter drains. It is a protection on that account. It keeps the steam out. Several times in Worcester we have had complaints from various sections of the city along this line. Some big manufacturers used large quantities of petroleum, and when they cleaned out their vats and turned the dregs into the sewer, where it united with the warm current of the sewage, a highly volatile gas was produced that rapidly spread over the city and ascended on to the hills and entered the houses of the people. A great many complaints came in, and on investigation we found where the trouble came from and were able to stop it. But a trap on the house drain is a protection against such a thing as that. Of course it may be said that if those houses were thoroughly plumbed, and all the joints were thoroughly made, the offensive air would not get into the house. But that is another subject on which there may be a difference of opinion, because that gas may be forced through the seal of the trap. And, as Mr. Craig said, the joints ought to be tight, but, as a matter of fact, they are not tight at all times.

Here is another reason for the house trap. Houses, of course, are built at various heights. The low building, with pipes going directly from the sewer up through the house, without any house trap, has a vent for the sewer. For some sewers are more offensive than others. In some sections, where there are tanneries and other large manufacturing plants, the sewage is more offensive than ordinary house sewage. A low house, with a pipe going through the roof alongside of a house somewhat higher, creates a condition where the sewer gas going through the top of the pipe of the lower house would blow into the windows of the house nearby that is higher. We have had complaints of that kind. Therefore, we have a rule in our ordinance that no soil pipe shall open within 15 ft. of the window of a house nearby, but shall be carried up above that window. Even with a house trap we require that. And the trap used in Worcester is, I think, almost exclusively of the pot character. And under our ordinance the bowl and the bath are trapped into one trap, which Mr. Putnam has recommended as a good thing. The traps are required to be back-vented, and the ordinance that is now pending in the city council

— a new ordinance — has eliminated, as Mr. Craig has said the present Boston law does, the back-venting of the upper fixtures, depending on the soil pipe itself to furnish the air without back-venting.

I am not here to advocate that the house trap is essential. I recognize the fact that this whole question is, to say the least, in a debatable state, and my mind is open about it. There is much to be said in favor of venting sewers through the soil pipe, and it might be said, of course, that if that was done throughout the entire city the offensiveness of the sewer would be so diminished by the multiplicity of vents that it would be hardly noticeable in any one place. But again that may or may not be true. The currents of air in the sewers themselves and the currents of the outer air may so change the action of the vent pipes that they would not work in one locality when they would work freely in another. There is not any question that the sewers in themselves are highly offensive at times. A case came within my own personal observation within two weeks. At the foot of the street where I live there was a perforated manhole covering midway between the car tracks. At times that wasn't noticeable, but at other times it was highly offensive, so much so, indeed, that I went to the superintendent of sewers less than two weeks ago and told him he ought to change that for a closed cover. He did change it and since then I have not noticed any trouble. But when it was offensive it was highly offensive, and there is not any question that sewer air is highly offensive at times and that currents of air moving in the sewers may have an effect. So that it is an open question whether or not vents all over the city would minimize it to such an extent that in any individual case it would not be noticeable. All of this leads me to the conclusion which I stated at first, that I think this question is so highly important, and involves so much in the matter of expense and so much that concerns our comfort if not our health, that some body of men competent to determine the matter ought to be appointed in some manner by some organization, or even by the state, which, it seems to me, ought to do it, because we have a state law regulating the business of plumbing, and under that law cities and towns have enacted ordinances which require large sums of money to be spent to carry out its terms. And the state, it seems to me, ought to appoint a commission of experts who would make a series of exhaustive tests and determine definitely and positively whether it is or

is not necessary to back-vent the fixtures, and also whether or not a house trap on a system should be maintained. I don't know that I can add anything else, except to say that I have been highly interested in Mr. Putnam's slides and that I feel I am here more as a searcher and a learner than as one able to impart any information.

CHAIRMAN JOHNSON. — We shall be glad to hear from Mr. Felton as to his experience at Brockton in the omission of the house trap.

MR. FELTON. — While the omission of the house trap seems to be regarded as more or less of a novelty, yet I can say that in Brockton for the last fourteen years no house trap has been installed on any connection with the sewer. We have some 3 000 to 4 000 connections, all of which are minus the house trap. Its omission is compulsory, and I have yet to hear of any complaint by reason of its omission. While the quotation of vital statistics is liable to be misleading, it is a fact that of all the cities for which statistics are given by the Massachusetts State Board of Health, with a population of over 25 000, I think the death-rate in Brockton is the lowest. This may or may not have any bearing on the subject. It is evidence, perhaps, of a negative character, in that it proves that the omission of the house trap is at least not of a very deadly nature. At the time of the installation of the system there was more or less controversy over whether this trap should be omitted, and a report was asked for from Mr. Rudolph Hering on that subject, and at that time he did not treat it as a novelty. He said the trap was omitted in many places in this country and quite commonly abroad. I have his report here. It is short and perhaps I had better read it in its entirety. This, you understand, was written some fourteen years ago, and possibly his mind may have changed on the subject.

[Mr. Hering's Report to the City of Brockton.]

VENTILATION THROUGH HOUSE DRAINS.

The ventilation of public sewers is important both to enable the air within the same to be kept at atmospheric pressure in order to prevent the traps connected with the system from being unsealed, and to cause an exchange of air within the sewers. The usual method of ventilating public sewers is to have perforated manhole covers and thus allow the ingress or egress of air at every street intersection, or wherever manholes are located.

Private sewers or house drains are usually disconnected from public sewers by traps, and are themselves ventilated by means of fresh air inlets provided for near the ground and generally at the sidewalks, by which the air enters and, after circulating through the house drains, is permitted to escape above the roof through the open soil pipe. There is no serious objection to this method of ventilating both sewers and house drains. A better way, in my opinion, because it is more effective, is to ventilate the public sewers through the house drains. When the other method is employed we generally find the fresh air inlets closed with dirt, or, in the winter, with snow and ice. The objection claimed for ventilating the public sewers through house drains is the supposed danger of getting sewer air into the house, if any pipe in the latter is not right. In my opinion the danger is more imaginary than real. The air contained in the pipes will escape at the larger opening above the roof, provided the pipes are properly dimensioned, rather than escape through small cracks in the rooms of the house, even should there be an imperfect joint. The same danger, however, is imminent from the house drains themselves if they are not air tight. The continual passage of air through them from the sewer will give them much more ventilation than if they relied on the so-called fresh-air inlet, and are thus found to be much cleaner. Any possible escape of sewer air from them will, therefore, be less offensive and less dangerous. On the continent of Europe, and particularly in the colder countries, it is considered decidedly preferable to ventilate the public sewers through the house drains. In our own country we have several cases of this kind. No complaints, as far as I know, have ever been made against the actual working of this method of ventilation either in Europe or in our own country.

To reduce the possible dangers to a minimum, and also for other reasons, it is my opinion that house drains should be under municipal control. This requirement seems to me to be even more important than the control of pipes for water and gas supply within the premises, because in the latter any defects at once become apparent. All house drains should be tested as to their air-tight condition after construction, and they should be so laid in the building that they can be readily examined at any time, and they should be so examined regularly at certain intervals.

There is another advantage arising from a good current of air from the public sewer through and out of the soil pipes which is of value in colder countries. The great current of air escaping at the top of these pipes renders them less likely to become choked in winter by frost than if there is but a small current in them, as would be the case if the fresh air inlets are small and partly stopped up.

If you can establish municipal control of your house drains and keep your sewerage well cleaned and flushed, the ventilation both of public and private sewers obtained partly by perforations in manhole covers, acting as inlets, and the

soil pipes in houses, acting as outlets, is the best and most thorough system of ventilating sewers.

(Signed) Rudolph Hering.

It seems to me, after our fourteen years of experience, that the danger is more imaginary than real, as Mr. Hering has said. Our inspector of plumbing informs me that he has never heard a complaint by reason of the odor from the pipes communicating to neighboring buildings. He spoke of a case in this city. He said that Boston recently, I believe, made this compulsory, or at least optional — perhaps Mr. Craig knows about that — and that a case was being fought by some one who was being compelled to enter. Whether that case has been settled I do not know. The contention of the complainant was, I believe, that the ordinance said the pipes should extend to the roof without obstruction, and the defense claimed that the trap was not an obstruction. It appeared further that the defendant in this case was not particularly against the method if made obligatory upon everybody, that is, if the law were made retro-active, so that all traps now installed might be eliminated. But he decidedly objected to having his houses used as a vent for the whole Back Bay, — I believe that is where the case occurred, — and as a sewer ventilator for the whole system. I don't know how that case was decided, whether the defendant was obliged to remove the trap or not. But he had very decided objections to its omission. Perhaps Mr. Craig knows about that case.

Mr. Craig. — That case occurred on West Street, I think. That was the first case of it. The owners objected to making their pipes vent pipes for the surrounding half mile square. I hear that they have got traps in. But there is a board of appeal attached to the city ordinance, and the board of appeal decided that it was optional with the owner whether he used the running trap or not. Don't get the plumber's condition confused. I am not against the putting in of the running trap or the taking of it out, only in reason. In the older part of the city of Boston it might be dangerous for the reasons mentioned by Mr. Coffey, and those observed by myself and others, to have the joints all warped out of position and loose. Admitting that sewer air is not very bad, a man doesn't want his job disintegrated from this matter of steam and heating. If that could be avoided I wouldn't have any objection whatever to it. If you are laying out a new section where a number of new houses are to be erected, it would be a fine thing to do. It would be a fine

thing for a residential place. The city of Newton has it and the people of that city don't find any fault with it. They think it is all right. It is hard to lay down any hard-and-fast rule. There is a great deal of force in what Mr. Hering said.

Mr. Felton. — It seems to me that with trap omitted a perforated manhole cover is entirely unnecessary. It is an objectionable thing for other reasons than the odor, and I have entirely stopped using it. When you have as many openings as you do in a system without traps, it seems to me the holes in the covers are but a small fraction of the total vent area and are unnecessary for ventilation.

Mr. Craig. — I did not mean that we should throw the law over. I did not mean that even if I said it. I meant simply that some simple form of looking after the installation of plumbing is all that we need. I have said so to the plumbers themselves. I reiterate it here. We have found that this legislation is hysterical and has led us into a lot of errors. Now we are going back to some simpler form of plumbing installation. That is what we are looking for, and the simpler the new form is the better we shall like it. We don't want a plumbing law so extraordinary that it will require the services of a lawyer to unravel it. It is a simple matter to put in a few pipes. We have had a lot of mystery surrounding it, and as a result everybody becomes alarmed and says a commission ought to act on it and ought to take it under advisement and dissect it.

Mr. Weston. — You believe in having principles established rather than details.

Mr. Craig. — That is it exactly.

Mr. Dorr. — May I say a few words about the house trap? All this discussion has been regarding the means of preventing sewer air from getting into the house. Sewer air is foul or not in proportion as the sewer is ventilated. If the sewer could be adequately ventilated there would not be anything deleterious about sewer air whether it got into the main stack or not. There are ways of ventilating the sewer. One is through the house system. The other is through perforated manhole covers. That is the system that has been adopted. And that has been found to be a very imperfect system. In the first place, at certain seasons of the year it won't work at all. When those perforations are stopped up with ice and snow, our system of sewers is practically unventilated, and when the sewers are suddenly filled with water, no matter what trap you have, the sewer air will be forced into the houses.

Now let us consider the relative importance of things. The sewer is the main thing. Isn't it better to adopt a system by which the sewer can be adequately ventilated and the sewer air rendered innocuous at all times than it is to go into all sorts of complications to prevent the air from getting into the houses? I agree with the gentleman from Brockton. If the running traps all over the city were abolished and taken away, then the perforated covers could be done away with and the sewer air would not be thrown out into the streets right under the windows, which is certainly a much greater nuisance than discharging it through the stack pipe.

Mr. Weston. — It is difficult to understand how one can apply the same rules in the case of a brand new sewerage system, with new houses and new streets, that one would apply in the case of an old city, where the sewers have been built on the combined system; where the sewers have sagged and clogged; contain deposits of decomposing and fermenting matter, giving off gases, and are not adequately ventilated. It is impracticable to lay down any law to cover all these conditions. Each city must establish general principles applicable to its own conditions and leave a good deal to the individual discretion of the city engineers and the plumbers who have to carry out the work.

I have received a letter from Prof. C.-E. A. Winslow, as follows:

"It seems to me that the difficulty with plumbing regulations arises mainly from the fact that plumbing has never been treated as an engineering problem. I do not use the word "engineer" in a narrow sense. I consider myself an engineer, a biological engineer if you like. On the other hand, I do not use the word "engineer" as synonymous with any worker in natural science. It seems to me that an engineer is not simply a man who utilizes the forces of nature, but one who attempts to obtain maximum results from such utilization at a minimum cost. That is, the element of cost-efficiency must always enter into the work of a real engineer. Now applying this generalization to our particular problem, it is possible to obtain varying degrees of protection against sewer gas. We can, for example, insist that every fixture shall be trapped, that is, that there shall not be constant open connection between house drains and sewers and apartments. This is a minimum. At the other extreme we may demand traps on individuals fixtures, each protected by a special vent pipe opening to the air above; and we may demand further a disconnecting trap between the house system and the sewer. Undoubtedly the first provision will keep most of the sewer gas out of our houses. Undoubtedly the second type of regulation will keep out more. The

original idea, derived, perhaps, from the time when sanitation was a branch of medicine and not a branch of engineering, was that all sewer gas must be kept out of all houses at all times, at all costs. That was perhaps a reasonable position when the danger from sewer gas was supposed to be very great. To-day, however, our views of this menace have materially changed.

"We know that the danger from sewer gas can lie only in two things: either in the transfer of infectious germs or in the presence of poisonous gases, which may gradually lower the vital resistance of the body. The early researches in bacteriology tended to show that the former danger, that is, the danger of transmitting disease germs, was not an important one, since bacteria are not readily detached from moist surfaces and are not present in large numbers in sewer air. It became pretty generally accepted in this country and in Germany that the danger of specific transmission of disease by sewer air was slight. In England, on the other hand, the older view still lingers, and within the last two years it has received important support from experiments carried out by Major W. H. Horrocks at Gibraltar and by Dr. F. W. Andrewes in London. These observers infected the lower traps of a plumbing system by pouring in cultures of specific germs, and afterwards detected the same bacteria in the air of the upper parts of the system at considerable distances above. It happens that for the last two years I have been at work on the question of bacteria in sewer air under the auspices of the National Association of Master Plumbers, and I have arrived at results which, while not contradicting those of Horrocks and Andrewes, throw a very different light on their interpretation. I have found that specific bacteria are indeed discharged into the air from the surface of foaming, soapy liquids, but that the quantitative air pollution brought about is extremely slight. It seemed from my earlier experiments that Horrocks and Andrewes had demonstrated a possibility, but a possibility of such slight numerical importance that it could safely be neglected. In order to test this view I examined 200 samples of air from 19 different plumbing systems in various buildings in Boston. Of the 200 samples of air taken from the inside of house drains, soil pipes, vent pipes and wastes, only 4 showed sewage bacteria, and those 4 were samples taken in the immediate presence and at the moment of local splashing. The air of the house drainage systems in all the other samples was entirely free from sewage bacteria and I calculated that if a person applied his mouth to the upper part of a house drainage pipe and breathed the air for twenty-four hours he would inhale fewer intestinal bacteria than he would ingest in drinking a quart of New York water.

"The practical conclusion from these experiments is, of course, that the danger of contracting specific disease from sewer air is slight. There remains, of course, the possibility that sewer air may predispose to certain epidemic diseases by a general lowering of the vital resistance. Whether this is true or not

we cannot at present say. The subject well deserves careful investigation, and I hope to make some study of it during the coming year. At present, the evidence that this phenomenon plays an important part in epidemiology is of a somewhat uncertain nature.

"In view of these facts it seems clear that while we are right in spending money for plumbing which is free from gross defects, we are not as obviously justified in recommending large expenditures for refinements like back ventilation systems and intercepting traps between the house and the sewer. The trapping of ordinary fixtures does away with most of the possible danger from sewer gas. There are plenty of traps which will give a reasonable degree of security against siphonage without back ventilation. I believe the money now spent by the community and by the householder in securing double and triple safeguards against the possibility of defective traps could be much better devoted to improvement of the milk supply or to some other phase of the campaign for public health, which we can actually prove to be of practical importance."

Mr. Andrew D. Fuller. — For the past ten years I have made a study of plumbing from the engineer's, the owner's and the plumber's point of view, and for some time have been intimately connected in a consulting capacity with a testing and inspecting bureau which constantly examines and reports on plumbing installations.

While the paper and discussion presented to-night are very interesting and useful to me, those who have not made a special study of plumbing may, perhaps, carry away some erroneous ideas from this meeting on account of not knowing the weight of opposing ideas not here presented, and the fact that most of the present plumbing is the result of influences other than scientific.

A great difficulty we have to work against is the general apathy of the public towards the drainage pipes within and without the buildings, and the disposal of the drainage. As a rule, what annoys the property owner is a leak or an odor; either will stir him to action and a temporary interest in the plumbing situation.

Even with a properly trapped system there are additional means of contaminating the air by reason of the unclean condition of the overflows of the different types of fixtures; some can be cleaned easily, although commonly they are neglected, and others, like the old patent overflow bowl, are so difficult to clean that they are rarely cleaned until the odor brings it to the attention of the user. This condition exists on the house

side of the trap. On the sewer side of the running trap the pipe in the ground is often badly laid. When there is no sewer in the street the disposal of the sewage is oftentimes a bad source of contamination for the ground and air immediately surrounding the building. Cities and towns go to a heavy expense to install a sewerage system, and then do not require even a majority of the buildings to connect with the sewer. If the owner has a cesspool on his premises, and is fortunately situated on a rise of ground, so that his cesspool underflows his own land and on to that of his neighbor, and his neighbor does not know it, the owner will not as a rule connect with the sewerage system. About the only way that one can get that owner or neighbor to connect with the sewerage system is to make a complaint to the local board of health. That is an uncomfortable thing to do, unless one has in his house some form of sickness which can be traced clearly to his neighbor's drainage. Such a complaint occurs so seldom that many a town forces its residents to a great expense for a sewerage system and then does not force the people to get the benefit of it. That is not right because the state sewer tax in the metropolitan district is assessed on the towns on a basis of population and valuation. The town generally bears some part of the sewer tax from the general tax levy, in some towns the whole tax and in others a part, the balance being made up by the abutters supposed to be benefited. Now the part that is assessed on the general tax levy is assessed on the farmer or the suburban man whose property cannot be connected with the sewer, for the reason that the sewer has not been, and perhaps cannot be, extended to his district. Yet his assessment is legally justifiable on the ground that the sewer is a general benefit to the community. As a matter of fact, the sewer system is not a general benefit to the community unless a large number, or the greater number of the houses, are connected.

This paper will help to arouse a greater interest among the people in the plumbing situation and in requiring better work. We have come across many violations of the law in regard to good plumbing and good workmanship. It is evident that neither the plumber nor the city inspector has done the work he ought. It is necessary to get the plumbers and the public more interested in the general situation and to endeavor, whatever the law is, to do better work, and to require better work. By this we shall get fully as much protection as we shall in the immediate future by changing the laws. I

am in favor of changing the laws gradually and have made a schedule of laws that it appears might be uniformly adopted. Those laws are made very simple in order to get something that the public, the city officials, the inspectors and the plumbers will back up and take an interest in seeing carried out.

[NOTE. — Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by July 15, 1909, for publication in a subsequent number of the JOURNAL.]

OIL AND GAS IN THE ST. LOUIS DISTRICT.

By H. A. Wheeler, Member of the Engineers' Club of St. Louis.

[Read before the Club, March 3, 1909.]

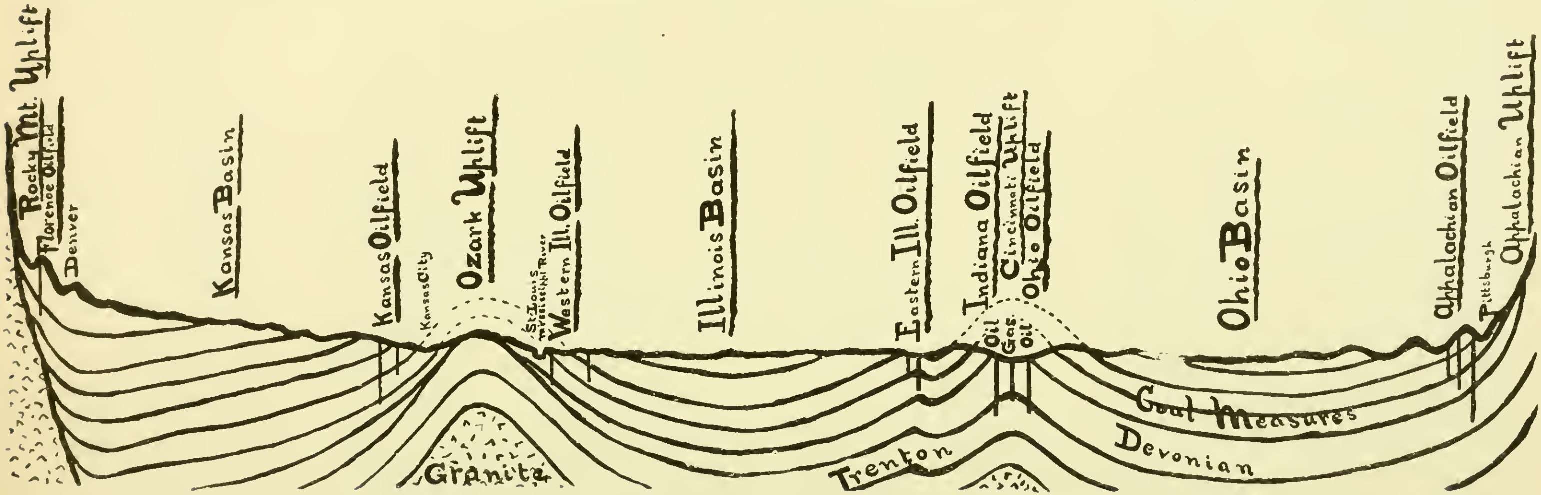
Early Efforts.

The great excitement that swept over the country in 1885 from the phenomenal success resulting from the replacement of coal by natural gas for industrial and domestic use about Pittsburg, stimulated drilling for gas all over the country. This prospecting resulted in opening up the magnificent gas and oil fields of western Ohio in 1885 and the prolific gas fields of Indiana in 1886. St. Louis became sufficiently interested in this ideal new fuel, which was so rapidly building up new industrial centers, that a committee of 100 public-spirited citizens contributed $100 apiece to investigate the possibilities of developing gas fields near St. Louis. Two experts were engaged, who while not enthusiastic as to the success of the venture, had a test well drilled at Marshall, just beyond the western outskirts of St. Louis, that was a failure. As the money gave out, a $25 000 stock company was formed to continue the work that had a deep well sunk to the Trenton limestone, the gas horizon of Ohio and Indiana, near Edwardsville, Ill., 20 miles northeast of St. Louis, which was also unsuccessful. Since this faint-hearted effort, St. Louisans have taken practically no interest in oil and gas, although one of the most important and most profitable oil fields ever opened has been developed within the past four years that is scarcely a hundred miles distant and a new field is on the verge of being opened almost at her threshold.

General Geological Conditions.

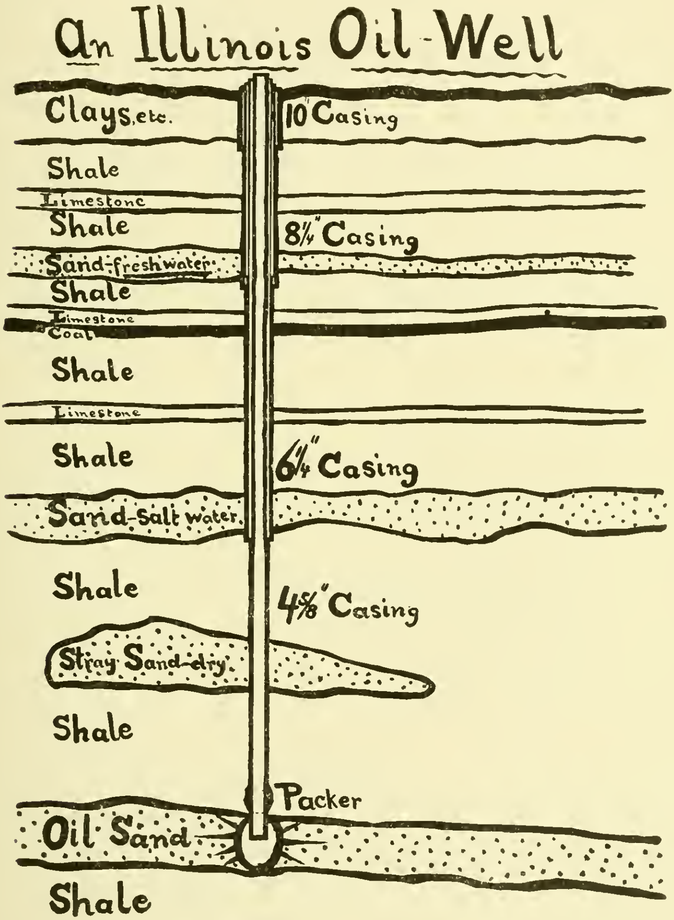
As oil and gas are geological products, the vital question to be considered in seeking new fields is whether the geological conditions are favorable; and since they have been produced from the same sources and are usually closely associated, the same general conditions of occurrence apply to both. Four factors are usually regarded as essential for the occurrence of oil and gas, or, (*a*) *suitable material to produce oil and gas*, such as bituminous shales and organic-formed limestones; (*b*) *a porous rock to hold it and act as a reservoir*, as coarse, open sandstones, conglomerate

Continental Section showing Location of the Oil Fields on the Flanks of the Uplifts.



and dolomitic limestones; (*c*) *an impervious seal or cover to prevent its escape*, as beds of shale or clay; and (*d*) *favorable structural conditions for concentration into paying bodies or pools*, such as anticlinal axes, domes, elevated terraces and arrested monoclines. Broadly considered, all these factors are essential, although the source of supply may be at a distance, from the travel of the oil and gas through a porous formation, while faulting may have sufficiently broken the cover that the gas has more or less completely escaped. All these conditions are found over a large portion of the country between the Alleghany and Rocky mountains, yet the number of oil belts therein are an insignificant percentage of this great area. A more careful study of the facts shows that there are two other factors that are highly important, although frequently overlooked by those who have had no experience, to wit: (*e*) *absence of artesian water circulation*, which would wash out or sweep away the oil and gas; and (*f*), *sufficient area to produce large or paying pools of oil and gas.* The very large number of deep water wells throughout the above area demonstrates the great importance of the absence of artesian circulation. In fact, the presence of fresh or potable waters precludes the presence of oil or gas, and until salt water is struck, which usually shows stagnant or non-circulating conditions, there is no hope of finding oil or gas. The importance of the last condition is shown in the accompanying diagrammatic section of the Mississippi Valley from the Alleghany to the Rocky mountains, which shows that all the important oil fields *occur on the flanks or sides of large basins.* Thus the famous Appalachian oil belt, which extends for 500 miles along the western flank of the Appalachian Mountains, is fed by a large basin to the westward. The western Ohio oil fields occur on the eastern flank of the Cincinnati arch or uplift and are fed from the east by the Ohio basin. The Indiana field occurs on the northern and western flank of the Cincinnati arch and is fed by the Michigan and Illinois basins. The new eastern Illinois oil field is along a well-marked anticline that is supplied by the Illinois basin. The still younger western Illinois oil belt occurs on the eastern flank of the Ozark uplift and is fed from the east by the large Illinois basin. The mid-continent oil field is on the western flank of the Ozark uplift and is fed from the west by the extensive Kansas basin. The Florence and Boulder oil fields of Colorado occur on the sharply upturned flanks of the Rocky Mountains, although faulting and dikes greatly complicate this field. The California oil fields show a similar occurrence along the flanks of upturned

measures, but faults greatly complicate the field difficulties. The peculiar pools of Texas and Louisiana occur on the sides of the Gulf basin, where exceptional conditions have concentrated the oil and gas into very prolific pools under domes of limited area.



It is extremely important, therefore, in prospecting for oil and gas, to primarily have a large feeding basin combined with the other requisite conditions. In such a basin, the upper porous beds may be subject to artesian flow and therefore carry fresh water, but the lower beds, that lie beneath the influence of artesian flow, will usually be filled with salt water. On the flanks of the basin the oil will be found floating on the salt water, while

above the oil to the crest of the anticlines or domes the gas will be found, unless through fractures it has escaped by leakage.

Value of Geological Aid.

When the evidence can be obtained and is intelligently used with good judgment and experience, geology is very helpful in locating and developing oil and gas fields. It can be very safely employed in condemning large areas that are hopeless for expecting *paying pools* and it can greatly reduce the time and expense required in opening up new pools. It has been grossly abused, however, by charlatans possessing a glib smattering of the subject, and it has also been used as a cloak by the horde of fakirs that live on the fringe of the oil industry. The latter, however, usually employ magic wands, forked sticks or divining rods, wizard fluids, electric boxes, blind boys and other humbugs to eke out an existence by deluding the unsophisticated with their self-proclaimed supernatural powers.

The Eastern Illinois Field.

Applying the evidence of geology to eastern Illinois, the conditions are ideal for expecting a valuable oil belt along a well-defined anticline. These conditions were known for many years and attention had been repeatedly called to them; in fact, Prof. T. B. Comstock almost lost his reputation in 1887 by the enthusiasm with which he advocated the development of what proved twenty years later to be one of the richest fields in the country. But the oil men, of whom only a very small portion attempt to "wildcat" or prospect for new fields, were surprisingly indifferent. They pointed to several holes drilled by Chicago parties in 1865 near Casey that showed only trifling amounts of oil and gas and to several "dusters" or failures drilled by local parties about Robinson in 1901 that were located along this anticlinal zone. In 1904, however, an old oil operator, J. J. Hoblitzell, was induced by local interests to again test the Casey district, where he leased up such a large block of land that he felt confident he could lead up to the oil pool should the evidence be favorable. Starting close to the old tests, his first well yielded some gas and a small amount of oil. Later holes showed more oil, but the wells were so light, or from 5 to 15 barrels, that the flock of oil men that were attracted by the discovery were so dubious that they refused to secure leases, which could then be secured at the insignificant rates of $1 to $10 per acre with $\frac{1}{8}$

royalty. Later they gladly paid $100 to $200 per acre with the much heavier royalty of $\frac{1}{6}$ to $\frac{1}{4}$ of the oil production. At last a 40-barrel well was brought in, when the other oil men stampeded to get leases and promptly began drilling in every direction. From the results of an army of drills, a well-defined series of pools have been developed along the anticline that extends over 90 miles on a nearly north and south line in five counties; the pools have a width of $\frac{1}{2}$ mile to 12 miles and the output has grown to the phenomenal production of 38 000 000 barrels in 1908. Such a rapid growth is unprecedented in American history. The famous Pennsylvania oil field, where the modern oil industry started in 1859, did not attain its maximum yield till thirty-two years afterwards, when it reached 33 001 236 barrels and it declined to 11 211 606 by 1907.

The Ohio field developed from a production of 661 580 barrels in 1885 to a maximum of 23 941 109 in 1906 and declined to 12 207 448 by 1907.

The Indiana field started with a production of 33 375 barrels in 1889 and attained its maximum of 11 339 124 fifteen years later.

The Texas oil field is popularly supposed to be the greatest producer ever opened, from the phenomenal output of the great Beaumont gushers in 1901. This is highly erroneous, as while individual wells duplicated the record of the Baku wells, in Russia, of 50 000 to 60 000 barrels per diem for a short period, the total production of the Beaumont field in 1901 was about 5 000 000 barrels. Since then several similar pools have been brought in and the maximum output was attained in 1905, when 28 136 189 barrels were produced.

The California production began in 1876 and has grown steadily, reaching 39 748 375 barrels by 1907; it is all low-grade or fuel oil with an asphalt base, like the Texas production.

The famous Baku district of Russia, the only foreign oil field that is comparable in importance with the American fields, occurs on the flanks of the eastern end of the Caucasian Mountain Range, with the basin of the Caspian Sea beyond. The oil occurs in tertiary measures and 57 143 097 barrels were produced in 1907.

The great magnitude to which the oil and gas industry has developed in this country is appreciated by so few that it might be well to state that it exceeds in value all our other mineral industries excepting coal and iron. The production in 1907 of crude oil or petroleum was 166 095 335 barrels, which was sold

to the refiners for $120 106 749. This is an average of 72 cents per barrel, and the prices ranged from 37 cents to $1.78, according to the quality and local conditions. The natural gas production in 1907 was 404 441 254 000 cu. ft., which realized $52 866 835; this is an average of 13 cents per 1 000 cu. ft., which ranged from 6½ to 73 cents. The panic of 1907 is said to have been checked by the importation of about $100 000 000 in gold, which with the additional credit it established, tided over the grave money stringency that caused the panic. Yet the value of the exports of refined and crude oil products last year amounted to $100 000 000, thus creating a trade balance in our favor that alone would extinguish the huge gold loan of 1907.

The production of the eastern Illinois field, of which 1908 is estimated, is as follows:

1905..........	156 502	barrels, valued at	$106 521
1906..........	4 385 470	,, ,, ,,	2 982 120
1907..........	24 540 024	,, ,, ,,	16 687 216
1908..........	38 000 000	,, ,, ,,	25 840 000

The Illinois oil is high grade as it has a paraffin base, a very dark green to brown color and a gravity of 30 degrees to 39 degrees B. Since the field opened, it has sold at the uniform price of 68 cents per barrel at the well to the refining trade, which is an excellent price for a new district that has had to be completely equipped with unusually liberal shipping facilities. A limited quantity from the Flat Rock pool is of lower grade and sells for 60 cents. Four 8-in. pipe lines have been laid into the district, and two more, one of which is a 12-in. line, are being laid to transport the oil to the refineries, most of it going to the large plants on New York Harbor. A $5 000 000 refinery has been erected near Alton, Ill., that has an 8-in. pipe line to the field, and two refineries have been erected in East St. Louis and a small one in St. Louis, that derive their raw material from this field. While no phenomenal wells have been struck, the average yield has been satisfactory, as new wells come in at 20 to 60 barrels, some exceed 100 and a few have yielded 1 000 barrels of oil per twenty-four hours. Very few "gushers" or natural flowing wells have been struck, and most of the wells have to be pumped from the outset. In the Casey district, or the oldest portion of the field, where the wells are four years old, they have settled down to an average production of 6 barrels. In the Robinson or central district, where the wells are about three years old, the average yield is about 20 barrels. In the

Bridgeport district, where the wells are about two years old, the average yield is about 40 barrels. The early production of the wells in all these districts was much higher and they have usually returned their cost in the first two to six months of their life.

The gas production in the eastern Illinois field has thus far been disappointing, as the yield is very moderate when compared with the magnificent oil output. Still the field is so young that it is premature to predict that most of it has been lost by faulting, as while this is being written a well has just been completed in "wildcat" territory that is very large, as it is rated at 10 000 000 cu. ft. per twenty-four hours. Thus far the gas has been found in the northern and central portions of the belt and it has a pressure of 50 to 150 lb. when derived from the 400 ft. sand and from 200 to 400 lb. from the 900 ft. sand. The value of the gas output in 1907 is estimated at $142 577, which is undoubtedly too low, as much is wasted by the oil men that is never accounted for.

The first pool opened is at the northern end of the field, between Casey and Westfield, in Clark County, where the oil occurs in a dolomitic limestone 20 to 40 ft. thick at a depth of 350 to 400 ft. At the Siggins pool, at Casey, a second producing sand is found at 600 ft. At the Robinson pool, in the central part of the district, the production has been obtained from a sand at 900 to 1 000 ft., but recently the 400 ft. sand has been found to carry paying quantities. At Bridgeport, at the southern end of the field, there are four "pays" or oil-bearing sands, or at 900, 1 300, 1 500 and 1 800 ft., the latter having been discovered only recently.

The eastern Illinois oil "sands" or sandstones occur in the coal measures, or in the same geological horizon that contains the Illinois coals.

The Devonian measures, from which most of the Appalachian oil is derived at depths of 2 000 to 4 500 ft., occur in the Illinois field at a depth of 2 000 to 2 400 ft. While very little drilling has been done to test the Devonian measures in Illinois, as the shallow sands have proved so productive and can be developed so cheaply, this may develop into another productive horizon.

The Trenton limestone underlies the Illinois field at a depth of 2 400 to 3 000 ft., but it has not yet been tested. As this is the formation in which occur the prolific gas and oil wells of Indiana only 90 miles eastward, it is quite encouraging in probably greatly prolonging the future life of this district.

It is interesting to note that the pioneer holes drilled in 1865 now prove to be on the western edge of the Westfield pool, and had they been located two miles farther east they would have been rewarded with success. Similarly, the several holes drilled about Robinson in 1901 to 1903 were about two miles beyond the eastern edge of the Robinson pool. Had expert advice been retained in these instances, both companies would probably have succeeded; for blank drill holes have a very high value, when the evidence they give is intelligently interpreted, as they show which way to push the work; and each company did ample drilling to have located the pool had such assistance been secured.

Probably 15 000 holes have been drilled in the eastern Illinois field since 1904, of which about 85 per cent have been successful, or the usual percentage in a developed field.

The Western Illinois Field.

Turning to the western side of the Illinois basin, we find the geological evidence fully as promising as on the eastern side; and when we turn to the collateral evidence that has led up to the discovery of other oil fields, it is even more encouraging.

Montgomery County. — Gas was accidentally discovered in 1882 near Litchfield, in Montgomery County, 50 miles northeast of St. Louis, in drilling for coal, that supplied that town (7 000) for several years and is still being used on the farm where it was discovered. Oil also occurred, of a lubricating grade, that sold for $5.00 per barrel at the wells and was pumped until 1902. The oil and gas occur at a depth of 650 ft. in a sandstone in the lower coal measures. Recently this same sand has been found to contain oil and gas at Butler, 10 miles eastward, where the latter was also discovered in 1907 in drilling for coal. With this evidence, as these wells indicate the fringe of a large pool, it should not be difficult to locate the main body of oil.

The Sparta District. — While the country was excited over the possible discovery of gas, and wildcat wells were being freely drilled, a test drilled in 1907 at Chester, in Randolph County, 50 miles southeast of St. Louis, struck gas at 900 ft. that yielded 3 000 000 cu. ft. per twenty-four hours at over 350 lb. pressure. This stimulated the drilling of over 20 wells in the town, most of which were so successful that it led to the great waste and extravagance that was so characteristic of that period. The gas was used for heating and lighting the town for about ten years before it was exhausted, and had care been taken to conserve the supply, it would probably be ample to-day.

After Mr. Hoblitzell, the discoverer of the eastern Illinois field, had sold out his extensive holdings at Casey at a very profitable figure, he began investigating the western Illinois field in 1906. He first went to Montgomery County, but finding that field leased up, he went to the Sparta district, where he leased considerable land. He began drilling that year and struck a light oil well in the first hole. Further drilling on a limited scale was unsuccessful until last fall, when he brought in a 20-barrel well and still later a 125-barrel well, which leaves no question as to the merits of this field. In the meantime a local company brought in a light oil well in 1907 and four more in 1908, of which the last is stated to yield 40 barrels. As a result, Sparta is now an active shipper, although tank cars have to be employed as no pipe line has as yet been built into the district. The oil is of a similar high grade as in eastern Illinois and occurs in a sand at the base of the coal measures that is 20 to 40 ft. thick and at a depth of about 900 ft.

St. Louis City. — In drilling for water in 1904 at the Welle-Boettler bakery, St. Louis, at Vandeventer and Forest Park avenues, a small body of gas was struck that supplied a couple of bake-ovens for several months. Several other wells were drilled in the neighborhood and small quantities of gas were found at Tamm's glue factory and the Fruin-Bambrick quarry, less than a mile south of the bakery. They are all on a very small anticline that shows in the face of the quarry. The gas occurred in a shale at a depth of 620 ft. at the base of the St. Louis limestone (of sub-carboniferous age). Of the two hundred or more water wells that have been drilled for water in and about St. Louis, in a very few instances trifling amounts of a heavy dark oil have been noticed that are remnants of probable large bodies that once existed before it leaked away. For St. Louis is so close to where the oil bearing measures of Illinois outcrop on the flank of the Ozark uplift, that it is not likely to be found in paying pools, as it probably escaped many million years ago.

Peters District. — In 1905 some farmers on the American Bottom near Peters, 10 miles northeast of St. Louis, banded together to put down a test well. Unfortunately they did not have the business sense to secure the services of an expert, but plunged blindly ahead and bought a drilling outfit. After two years' work and the expenditure of over $7 000 they reached a depth of 1 400 ft. and struck some oil, but the work was so bungled that it is unintelligible whether it was a paying producer or not. This stimulated the drilling of several holes in the

neighborhood, of which the last one, recently completed on the Watts farm, is said to be a 20-barrel producer. This is a very important discovery as it is the best grade of oil thus far found in Illinois and it occurs in the Devonian formation. It is the first production obtained from this horizon, and as it underlies all the other oil fields, it bespeaks a very bright future for a long life to Illinois as an oil producer. For when the present large reservoirs are exhausted in the more shallow coal measures, this lower Devonian horizon may be able to maintain the present heavy production. The Devonian is the formation from which most of the gas and oil of Pennsylvania and West Virginia are derived.

Pike County District. — In 1890 gas was struck at 168 ft. in drilling for water near Pittsfield, in Pike County, in western Illinois, and the gas has been used ever since at the farmhouse. No one else thought of using the gas till 1905, when another farmer had a similar experience, who also utilized the gas for heating and lighting. This stimulated drilling by the neighbors, until to-day a gas belt has been developed that is about 10 miles long by 4 miles wide, along which nearly every farmer now has his own gas well. The wells are along a well-defined anticline, and as they are only 100 to 300 ft. deep, depending on the rough topography, the pressure is light. The gas comes from a dolomitic limestone of Niagara age, which is even lower than the Devonian formation and hence is of the greatest significance in bearing on the future life of the fields now producing from the shallow coal measures. For should this deep horizon carry oil and gas under the other fields, it adds greatly to the resources of Illinois.

Centralia District. — Oil was struck last September in a test well drilled near Centralia, 60 miles east of St. Louis, which after being shot with nitro-glycerine, proved to be good for 20 barrels. More recently another well has been brought in that is good for 40 barrels, a very satisfactory production. The oil is of an excellent grade and comes from a sand in the coal measures at a depth of 600 ft. The structure that has been the cause of the pool is an arrested monocline, as the usual dip of 10 ft. per mile to the eastward has been arrested by a fault. This is unusual in Illinois, where anticlines usually mark the oil and gas pools, although it is quite a prevalent type in the California oil fields.*

* Since the above was put in type, an extension of the Centralia field has been found at Sandoval, about five miles north, where oil has been struck in a deeper sand, or at 1 400 feet.

Future of the Western Illinois Field.

To-day the development of the western Illinois oil field is in its incipiency and its small production seems insignificant when compared with the phenomenal output of eastern Illinois. But there was also a period when not only had eastern Illinois a small production, but the oil men were most skeptical as to its ever developing into an important producer. Sufficient time has elapsed to correct the latter mistake, but it remains for future development to attain the large production that western Illinois assuredly promises. Sufficient work has been done to verify the promises held out by geological investigations, and it now requires properly located drill holes and the capital to put down the drill holes to reap the generous reward that follows success in the oil industry.

[Note. — Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by July 15, 1909, for publication in a subsequent number of the Journal.]

THE FIRST INTERNATIONAL ROAD CONGRESS AT PARIS IN OCTOBER, 1908; WHAT LED UP TO IT; ITS DELIBERATIONS; AND ITS RESULTS.

By Austin B. Fletcher, Member Boston Society of Civil Engineers.

[Read at an informal meeting of the Society, March 10, 1909.]

Introductory.

This paper will relate mostly to macadam roads and motor vehicles, for, at the present time, no one who has to do with highway work ever thinks of the one without also considering the other.

Many writers have referred to good roads as being among the chief assets of a country. That statement is a truism, of course, but most roadmen now look upon the macadam roads under their charge as a liability and not as an asset.

The country road problem seemed to be fairly well settled and on a tolerably comfortable basis in Massachusetts until the year 1906, but since that year the roadmen here have not ceased to guess whence the money is to come with which to restore the damage done by motor vehicles.

Prior to 1906 the roads wore out and had to be repaired, but as a rule, when constructed properly, they wore smoothly and in a way that was understood and which could be provided for. Motor vehicles were also in existence before that year, but they were better behaved than those which came later. They were mostly low-powered machines and in the early days of "automobilism," as some of the French engineers call it, speeds in excess of 15 miles per hour were not so common as now.

In the year 1903, when automobiles were first registered in Massachusetts, 86 per cent. were of less than 10 h.p. In 1906 only 24 per cent. were of less than 10 h.p., 57 per cent. were between 10 and 30 h.p., and 19 per cent. were in excess of 30 h.p.

At the present time the average automobile operates most comfortably at a speed of about 20 miles per hour, but this speed is by no means the maximum at which cars of to-day are capable of being operated. On our open country roads it is probable that a rate of 20 miles per hour is more often the minimum speed of most of the drivers.

In 1903, in Massachusetts, 3 743 automobiles were registered; in 1906, 6 572, and in 1908, 18 052. In England and

Wales in 1904, 51 549 automobiles and motor cycles were registered, while in 1907 the number is given as 123 975, an increase at the rate of 45 per cent. per annum. In France, in 1907, it is said that the automobiles numbered 32 530, while in the entire United States, in the same year, there were 130 000.

Lord Montagu, member of the Council of the Roads Improvement Association of Great Britain, is responsible for these figures outside of those relating to Massachusetts.

The difficulties which we in Massachusetts began to realize in 1906, were perhaps felt earlier in England and France, because in those countries the more powerful cars were developed earlier. Also they had a greater mileage of macadam roads than we had in America and had perhaps kept more careful records of maintenance costs.

Some English figures are interesting, and from the reports of the Local Government Board for the years 1901 and 1906 it will be found that the maintenance costs, not including any payments from loans, were as follows on the rural macadam roads of England and Wales. (A pound is reckoned for convenience as equivalent to $5.00.)

	Mileage.	Cost.	Average Cost per Mile.
1900–1901,	23 394	$7 022 500	$300
1905–1906,	23 991	8 622 945	360

These figures show an advance in cost of maintenance of 20 per cent. during the five-year period. It is said that a comparison between the figures of 1901 and those of 1908 would indicate a considerably greater increase in cost than those for the years cited, but the actual figures are not yet available.

The rural main roads in the seven counties close to London, according to Mr. H. P. Maybury, county engineer for the county of Kent, showed during the same period an increase of nearly 38 per cent., and at the end of the fiscal year in March, 1907, the increase was nearly 48 per cent. in excess of the cost in 1901.

In Massachusetts, so far as its state highways are concerned, the problem has been a peculiar one. The state began building its roads in the year 1894, and the work has continued at a uniform rate, about 50 miles of macadam road being built per annum, until, at the end of the year 1908 the total length of state highway was approximately 740 miles. The average age of the road surfaces was then about seven years. In the early days of the work the roads were maintained properly, in that they were

always kept smooth, and ruts and holes did not exist. Under the steel shod traffic of those days sufficient binder was worn off the stone to replace such as the winds and rain removed, and, with an occasional dose of sand, sparingly applied, the roads were always in excellent condition. To keep them so, including such gutter clearing, grass mowing and cleaning of catch basins as was necessary, an expenditure of about $100 per mile per year seemed to be enough, but little or no provision was made by that sum for substantial resurfacing. The commission was, of course aware that such resurfacing would be necessary, but from all indications it was thought that the average time for such resurfacing would be somewhere between twelve and fifteen years from the date of construction. Just as it was about to impress upon the legislature, the source of all moneys for state highway purposes, the fact that greater appropriations for maintenance would be required, the motor vehicle began to increase and multiply, and with it came all sorts of trouble.

Fortunately, the Ways and Means Committee, some of whom are motorists, were able to recognize the difficulties in which the commission was involved, and the appropriations were increased somewhat. In 1908 there was available for maintenance $230 000, or an average of about $324 per mile for the 709 miles then under maintenance, and this year the commissioners have hope that $400 000 will be available for the 740 miles now constructed, or an average of about $540 per mile. This is somewhat better, but when the engineers' reports indicate that nearly $1 000 per mile is now needed to restore the roads to that degree of perfection which the public has a right to expect of a state highway system, the anticipated appropriation hardly seems to be adequate.

It should not be understood that the commission thinks that $1 000 per mile is to be the future cost per mile per annum for the maintenance of the state highways, but rather that if that amount were available this year, the roads could be put into such condition that the annual cost per mile in succeeding years would probably not be in excess of $400, and possibly $350 would be sufficient.

Now of this seemingly extraordinary amount which is immediately needed, the engineers estimate that about 50 per cent. is due to the high-powered automobiles.

So much for Massachusetts. In New York the problem is the same or even worse. There they have more miles of macadam roads and also more automobiles. Mr. Parker, chairman

of the Highway Commission, is there to-night telling the Solons of the legislature and the newly-organized highway commission what they do not know of the difficulties which are before them.

You may be wondering where the First International Road Congress comes in. That will be reached presently, but it seemed proper to tell first something of what led up to it.

No less a person than M. Barthou, minister of public works of France, has said: " It is to be lamented that large numbers of motor cars traveling at high speeds are destroying the great arteries of communication in all countries. Macadamized roads are being worked out of existence and new methods of road building must be introduced. Our road builders find themselves in face of a most difficult problem, that of adapting the roads to the new means of locomotion."

And the magnitude of the problem across the water is better understood when it is stated by M. Lethier, Inspecteur Général des Ponts et Chaussées, that a partial estimate of the length of the roads in fourteen of the governments of Europe alone is 994 000 miles (for the most part of macadam construction), representing in value $5 000 000 000, and an annual expense for their upkeep of not less than $160 000 000.

In the United States it has been estimated that there are about 2 151 000 miles of road, of which only about 38 000 miles are of the macadam type. We seemingly should be congratulated in not having to maintain, under the new conditions, any greater mileage of macadam roadways of the old type.

The Congress.

Early in 1908 the French government, by its Department of Public Works, notified all of the governments of a proposed congress to be held at Paris to consider all road matters, and particularly to discuss ways and means to adapt the roads already built to the increased wear and tear to which they are now subjected by reason of the prevalence of motor vehicles.

The governments and states were requested to send delegates to the congress. For the United States of America, the President appointed a commission composed of Logan Waller Page, director of the Office of Public Roads, Washington, D. C., chairman; Col. Charles G. Bromwell, U. S. A., superintendent of buildings and grounds of the District of Columbia; and Clifford Richardson, member of the American Society of Civil Engineers of New York, expert in bituminous pavements.

His Excellency Curtis Guild, governor of Massachusetts, appointed Harold Parker, chairman of the Massachusetts Highway Commission, and the writer of this paper to represent the state of Massachusetts.

The other states were represented by the following-named delegates:

New Hampshire: Arthur W. Dean, state engineer.

New York: Philip W. Henry, Nelson P. Lewis and Charles Withington.

Illinois: J. H. Foster and H. H. Gross, of Chicago.

Maryland: Walter W. Crosby, chief engineer Maryland Highway Commission.

Washington: Samuel Hill, R. H. Thompson and Samuel C. Lancaster, of Seattle.

The total number of delegates registered, 2 250, indicates the interest felt in the subject by the highwaymen of the world.

The Congress was formally opened at the Sorbonne on Monday, October 12, 1908, at ten in the forenoon. The great amphitheater was packed with delegates from everywhere, nearly all of whom were in evening clothes, and it is fair to presume that not 50 per cent. of those present understood much of the eloquent addresses of welcome made by the Minister of Public Works and other dignitaries.

Replies were made by the chief delegates of the foreign nations, and when the American and the English delegates made their addresses in the English tongue, the Americans present felt more at home.

Mr. Page, for the United States, paid a very handsome compliment to the French nation for its pre-eminence in road matters, and particularly to the French engineer, Tresauguet, who had much to do with the French system and its methods of construction and maintenance.

Speaking for Great Britain, H. Percy Boulnois, M. Ins. C. E., among other things said: "It is a matter for congratulation that the first road congress should be held in Paris, the home of the Pont et Chaussées, that unique institution which has existed since the year 1712 and done so much to make the French roads the envy of other nations. But the time has come when the traffic is changing rapidly and the engineers of the future will be called upon to design a different description of road. The heavy traction engine requires the strongest possible roadway; the bicycle, a surface as level as a billiard table; and the speedy motor car a road to itself. It is impossible to make a dustless

road, but a road can be made which will not manufacture dust. There are engineers all over the world who are quite capable of making roads for the traffic they are called upon to carry. It is a question only of expense."

Methods of the Congress.

In the call for the Congress it was stated that the Congress would consist of: First, plenary sittings; second, sectional sittings; third, an exhibition of materials and machinery; fourth, excursions.

The subject matter to be discussed was divided into two classes: First, construction and maintenance; second, traffic and working. Papers on these subjects were solicited by the organizing officials from road experts all over the world for presentation in printed form to the members, the intention being that they should be available several weeks before the Congress assembled. In all, more than one hundred were received. Owing to the labor involved in translating and printing so great a number of papers, the work was delayed, and the American members did not receive their copies until they reached Paris. On this account the Americans were at some disadvantage.

The writer is sorry to say that at least one of the American delegates has not read all of the papers yet. He has found that in the eighteen or more years since he was cutting as many of his French recitations as the professor would stand for, he has lost most of his French vocabulary, and thumbing the dictionary is slow work.

Some weeks before the Congress assembled, a committee, composed entirely of French officials, so far as could be learned, met at Paris and framed a number of resolutions, based upon the reports referred to, for submission to the Congress. Some such method was necessary, but it is to be regretted that the other nations were not represented on the committee.

Sectional Meetings.

In order that the resolutions framed before the Congress assembled might be discussed by the members, the organizing committee provided for two sections, each meeting simultaneously in two halls in the Jeu de Paume. The first section was to discuss the resolutions bearing on "Construction and Maintenance," the second to consider "Traffic and Working."

Each section had its bureau officials composed of the chief

official delegates, who sat on the platform, while the lesser delegates sat on the benches below. Your fellow-member, Mr. Harold Parker, occupied a seat on the platform in the second section as one of the vice-presidents of the bureau.

The procedure was the same in both sections. The arguments in favor of the resolutions were read in French by some delegate apparently chosen before the Congress met, and then all the members had an opportunity to express their views.

As the proceedings were all in the French language, many of the English-speaking delegates were utterly unable to understand what was going on, and early in the Congress, at the instigation of Mr. Samuel Hill, it was arranged that the English and American delegates should meet in advance of the regular sectional sittings and discuss the resolutions which were to be acted upon later in the day. Provision was made for translation into English of the pending resolutions. This plan worked very well in so far as it informed the delegates of what was going on, but it appeared to be unnecessary to make any radical changes in the resolutions as presented for reasons which will be stated later. It seemed to be impossible to introduce any new question not included in the resolutions framed in advance of the Congress, and no attempt was made to do so.

The sectional meetings were well attended and there was much debate upon the resolutions, but apparently there were very few, if any, changes made in the cut-and-dried tentative draft.

Each day as they were acted upon in the sections, the resolutions were handed up to the Bureau Generale for presentation to the Congress at its final session.

Exhibition.

Connected with the Congress, in the Jardin des Tuilleries, was an exhibition of road machinery of all kinds, as well as a number of patented pavements. The writer attempted to get a comprehensive set of photographs of the exhibits, but after exposing several negatives, a gendarme stepped up and remarked in excellent French that he must first get a permit from the management. Possibly a franc of two would have smoothed things over,— Baedecker says it usually does in France,— but he took no more pictures.

The most interesting machines were those for distributing or spraying tar and other bituminous materials on road surfaces. While there has been much talk about such machines in 'this

country, no satisfactory sprayer has been yet manufactured here. Several of these machines are self-propelling, the motive power being an automobile engine. In all of them the material is heated in the machine and is sprayed upon the road through nozzles of more or less complicated design by means of compressed air generated by the machine itself. It is by means of the use of such machines that the English roadmen are able to make a single gallon of tar spread over from 7 to 9 sq. yd. of roadway, while we in this country without a spraying machine and relying upon brooms to distribute the tar, are unable to make the same quantity spread over more than 3 to 4 sq. yd.

Most of the exhibits of road materials apply only to European conditions, and some of the samples of stone recommended for macadam purposes appeared to be of an inferior nature, and by no means so good as the average of the stones used on our roads in Massachusetts.

Excerpts from Some of the Papers Prepared for the Congress.

As already stated, more than one hundred papers were prepared for the Congress by engineers and others from all over the world.

From the conclusions arrived at by the authors, the writer of this paper has selected some significant remarks relating mostly to macadam roads and bituminous binders, which appeared to him to be interesting.

If it should be suggested that there is a preponderance of excerpts from the papers of the Englishmen and Americans, the writer would explain that this fact is not so much due to his weakness in the foreign language, to which he has already made confession, but rather to the fact that John Bull and Brother Jonathan got down to "brass tacks," as the saying is, more than did the other nations. All of the conclusions were translated into English.

Col. Charles S. Bromwell, superintendent of public buildings and grounds, Washington, U. S. A. — . . . The advent of the motor car and its ever-increasing use, however, have introduced new complications into park systems of roads. Designed and built originally for iron-tired vehicles, it was soon found that the construction of these roads was not adapted to the use of motor cars. These heavy, fast-moving cars cause an excessive wear of the road surface, which is unlike the wear

caused by ordinary vehicles, and the road does not tend to repair itself. The wheels are of smaller diameter and of greater tread, and have a greater velocity and a greater area at the point of contact with the road surface. The elastic material of which the tire is made has greater coefficient of friction than the tires of ordinary vehicles. The action, therefore, of the driving wheels of the motor car can be compared to that of a powerful revolving brush which brushes away the top surface of the road, acting with a displacing force as high as 200 lb. to the square inch. The dust so ground away is thrown out by the wheels or moved by eddy currents and blown by the wind entirely off the road. In time, all this fine material, whose function it is to fill in the interstices between the larger stones and to compact the road surface, is entirely removed from the road. This action of motor cars on roads is perceptible in dry weather when the cars are traveling at a rate of 10 miles an hour, and at higher speeds is plainly evident. Most motor cars are so geared that it is not convenient nor agreeable to travel on the high speed or direct drive at a rate less than 12 to 15 miles an hour. This fact, as well as the natural inclination of the driver to drive his car as fast as the speed regulations permit, tends to make the wear greater. This wear is also increased by the occasional use of tire chains, or other anti-skidding devices. . . .

Logan Waller Page, director United States Office of Public Roads, Washington, D. C. — . . . It has deen demonstrated by connecting both front and rear wheels of motor cars with separate speedometers that there is a considerable amount of slipping of the driving wheels on the road surface, and, on account of the numerous irregularities on the average road surface, this is what should be expected. This slip, due to the decrease in the bearing surface of the tire, undoubtedly increases the amount of finely-divided material of the road surface thrown into the air. The increased amount of damage done on this account will be in proportion to the irregularities in the road and the speed of the car. While it is an important factor, its effect is greatly reduced if the road has a smooth surface. . . .

Beyond a doubt the most injurious action of motor traffic is the great tractive, or shearing, force exerted by the driving wheels of these cars. The fine dust which ordinarily acts as a cementing agent to the road surface is thrown into the air to be carried off by the wind, or that remaining on the road is so loosened that it is easily washed into the gutters by rain. The pneumatic rubber tire wears off from the broken stone of the

road little or no dust to replace that thus removed, and the result is that the stones become loose and rounded, giving the greatest resistance to traction and allowing water to make its way freely to the foundation of the road. . . .

M. Renardier, ingénieur en chef des Ponts et Chaussées, à Orléans. — . . . The principal complaint made is the cloud of dust raised by the passing of an automobile. Wear and tear of the roadway is relegated to a secondary place. At least forty passages a day are required to show any wear due to this mode of travel. It is only when they are near a hundred that injury to the roadway must really be considered. . . .

M. Moissenet, ingénieur en chef des Ponts et Chaussées, à Montauban. — . . . Nothing better can be done than to insist on the exactness and excellence of the points contained in the following passage from the "Cours de Route," by Durand-Claye (1880): "Ruts can be prevented by intelligent maintenance. They can be prevented just as effectively by diminishing the crown, so that, while allowing the water to run off easily, it becomes insensible for horses and for persons riding in carriages. Nothing then causes them to keep in the middle of the road rather than on the sides, and circulation is established nearly indifferently over its entire width. Experience gives a limit for the crown which should not be exceeded in order to reach this result. . . . To-day it has been fixed in France at 1–50." And the conclusion has been reached that it would be a delusion and a snare to seek economy in the maintenance of a roadway less than 5 meters in width. . . .

Drummond & Stevenson, of the Road Surveyors' Association of Scotland. — It is generally admitted that tar is the best binding material which has yet been found to meet the requirements of present-day traffic. The method of using it, however, is a question which has to be considered from the economic standpoint more, perhaps, than the technical. . . .

It might be stated that it has been computed that in urban and suburban areas where macadamizing costs 9d. or more per superficial yard for maintenance, it is better policy to adopt some method of paving. . . .

It may also be stated that tar should only be used in conjunction with macadamizing when the road to be treated is well bottomed or has such a coating of metal as to be equal in strength to a well bottomed road.

There are several methods of using tar which may be considered in their order of wear and cost:

(*a*) Tar-macadam.
(*b*) Tarmac.
(*c*) Spreading matrix before applying metal.
(*d*) Tar spraying before rolling.
(*e*) Tar spraying or painting after rolling. . . .

M. M. SIGAULT, ingénieur en chef, et LE GAVRIAN, ingénieur des Ponts et Chaussées, Chàlons-sur-Marne et Versailles. — . . . The surface of petroleum or of oil is effective, but it costs a great deal in France; aside from this it can be recommended for macadam of every kind, provided that it be renewed, if necessary, at the beginning of the bad season in countries where the winter is very damp.

Application of tar is the most effective process yet tried. Not only does it prevent the formation of dust, but it protects the roadways against the destructive action of automobiles going at high speeds.

It is to be recommended for roadways exposed to this sort of circulation, and, in towns and cities, on public highways traversed by ordinary vehicles.

It should only be applied, however, when certain conditions of climate, exposure and character of the roadway are combined.

H. T. WAKELAM, member Institute Civil Engineers, county engineer, Middlesex, England. — . . . The author strongly reiterates the remarks contained in his paper sent up to the Association of Municipal and County Engineers, London, in June, 1906, viz., that the best method for remedying the dust nuisance on main roads, at a cost which can best be borne by the already over-taxed rate-payers, lies in the adoption of sufficient surface tarrings, combined with the use of the toughest basalts and granites procurable. Such tarrings can now be quickly carried out by the use of either mechanically propelled or horse-drawn machines. Smaller machines, spreaders and sprayers, for use by hand, can also be purchased at reasonable prices. . . .

M. SPIESS, Gr. Herz. Reg.-Baumeister, à Karlsruhe. — . . . In certain cases, the tarring of a road subjected to very important heavy traffic may prove efficient, if the road is so laid that it is able to be well drained. The expense for the treatment is thus reduced by about half or three quarters as a result of the diminished outlay incurred in the cleaning of the road and the renewal. On roads with strong metal surfaces not treated with tar, the rate of the maintenance expense would probably be still greater by one half or three quarters of the cost of tarring than it would be if the road were tarred. . . .

M. LE DR. GUGLIELMINETTI, Monte Carlo. — . . . In the city of Paris alone the tarred surface has increased from 21 000 square meters in 1904 to 360 000 in 1907. . . .

But it is perfectly understood that these good results are not to be obtained on no matter what macadam road. They depend largely on the kind and density of travel, and that is why a choice must be made among the roads which are to be tarred. If tarring cannot replace asphalt or paving on roads subjected to heavy trucking, it gives, on the other hand, excellent results on roads of average travel and especially on roads where automobile travel is even very intense; because the skin of tar prevents the pneus (*sic*) from sucking up the binding material, and for this reason removes to a great extent the grinding down of the roadway. . . .

THOMAS AITKEN, county surveyor, Cupar, Fife, Scotland. — *Tar macadam*. . . . Unquestionably tar-macadam, or tarring roadstones in some form, will be the future method of constructing highways in this country, especially on main roads. The tar or tar-compo, as a matrix or binder, in conjunction with a limited quantity of whin or granite chippings and dust, effectually binds the roadstones together, and forms a homogeneous and solid mass. This system of construction eliminates internal friction and wear of the metal coatings, a condition of things inseparable from ordinary macadam. By confining the actual wear of the roadstone coating at the surface, comparatively little abrasion of the metaling takes place, hence the life of the road will be considerably lengthened and ultimate economy promoted in its maintenance.

The use of tar-macadam dates back for about fifty years in this country and, according to Mr. Arthur Brown, A. M. I. C. E., borough engineer, Nottingham, that borough was generally understood to be the place of origin of asphalt pavements and of macadamized roadways. . . .

. . . It is apparent in order to attain good results in an economical manner, that some form of mechanical apparatus is necessary to treat the roadstones properly immediately these are spread on the road. Such an apparatus can traverse the metal coating, spraying the viscous liquid, under considerable pressure, and forcing it down and under the loose stones, covering them entirely with a film of tar or tar-compo. When this has been accomplished, three or more turns of the machine being necessary, depending on the depth of the roadstone coating, whinstone chippings are then applied in limited quantities to fill the inter-

stices of the metal coating. The roadstones are rolled quite solid and another application of tar is sprayed over the surface by machine, chippings and dust are sprinkled over, and the coating completed by further rolling. By this means the requisite amount of tar necessary to ensure good results is applied, and coatings up to four inches in depth can be treated by this spraying machine. By applying the matrix material in this manner, each stone receives a proper amount of binder and all danger of an excess of tar being introduced in the structure of the road is obviated, which would otherwise be a disadvantage. This cannot be attained by hand labor or by machines which depend entirely on gravity for discharging the liquid material.

The amount of chippings necessary to fill the voids in order to make the coating a homogeneous mass depends on the gage of the roadstones used; the smaller the size the less will be the quantity of chippings required. In this case, as is common with all descriptions of tar-macadam, the nature of the stone is an element to be considered; materials which break with a rough fracture are to be preferred to stones having a fine texture.

This system just described is, in the writer's opinion, the cheapest method of making a tar-macadam road, and it is quite as efficient as any other system. It is, however, absolutely necessary that all materials should be thoroughly dry and the work carried out in fine weather.

The matrix, if it is of refined tar, must possess sufficient toughness to bind the stones together and form a waterproof surface. If the process of refining is not carried out properly so as to rid the tar of ammoniacal liquor and naphtha, then the oxidizing influence of the air will effect it adversely, while if the process is pushed too far the tar becomes brittle after setting, and it is then easily pulverized by the wheels of vehicles.

The difficulty is in getting the proper grade of tar for this class of work, and for this reason many excellent compos, containing a percentage of bitumen, have been introduced for this purpose. These, for the most part, set hard and appear to be ideal compositions for forming a matrix or binder for tar-macadam. . . .

. . . Machine broken metal, when of a good description and properly screened, is better capable of being compressed into a solid mass than hand-broken macadam. In this respect, when making tar-macadam *in situ*, it is preferable to use machine-broken screened material, because by the action of the roller wheels the stones assort themselves into proper position and

become wedged and therefore occupy the least possible bulk, with a minimum of interstitial space, which is filled with a matrix of tar or tar-compo and whinstone chippings. . . . It is open to discussion whether tar-macadam made with various grades of stones and thoroughly well mixed, as in the bithulithic system, can resist and maintain a good surface in an equally efficient manner as a road coated with stones of approximately equal size treated *in situ* and held together with a matrix of a bituminous nature. The gage of the roadstones is also a factor in regard to the quantity of matrix or rather compo used in making a road. If the size of the roadstones is considerable, say 2.5 in. in diameter, then the amount of voids is such as to require a comparatively large quantity of binder to properly fill the interstices. This at once introduces the fact that, while a homogeneous mass is obtained, the cost of construction approximates that of an asphalt pavement. It is of great density, but for country roads a cheaper form of construction is required, and in this matter the roadstones composing the coating should, if of proper quality, take up the wear of the traffic, and the matrix, instead of partly bearing the burden of wear, should only be considered as a binder and utilized as such. . . .

. . . From experience, the writer, while admitting that material of promiscuous grades properly assembled may somewhat reduce the voids, favors the method of construction where stones of practically equal size are used in order to ensure uniform wear at the surface and therefore greater durability which is an essential factor. . . .

The cost of making tar-macadam *in situ* varies considerably, depending on the percentage of bitumen, or such like material incorporated with the tar. If ordinary refined tar is used, obtained at about 1½d. per gallon, the cost is about 6d. per ton of metaling consolidated, or about ¾d. to 1d. per sq. yd. of road more compared with ordinary macadam construction. Should, however, a tar-compo be necessary or desirable in order to combat with very heavy traffic, then the price increases according to the percentage of bitumen introduced into the mixture. The compos used in Scotland vary in price, but the best, and probably the most satisfactory in the long run, averages from about 3¼d. to 4d. per gallon. Tar-compo at the latter price, applied to a 4-in. coating of metalling, represents, including application, approximately 4d. per sq. yd., or a difference of about 2d. in excess of ordinary macadam. . . .

The system of spraying a bituminous mixture by mechanical

means to form *in situ* tar-macadam, introduced by the writer many years ago, has proved successful in every particular and is well adapted to modern requirements. . . .

E. Purnell Hooley, member Institute Civil Engineers, county surveyor of Nottinghamshire, England, president of the Institution of Municipal and County Engineers. — . . . The author has tried every ordinary system of road making that it is possible to try on country roads, and has arrived at the conclusion that the only possible means of making a reliable road, suitable for all classes of traffic at all times, is that which has been carried out by the county council of Notts in several parts of the county.

This type of road means, instead of allowing the road to wear itself out by attrition, weather or traffic, and encourage the maximum of dust, to entirely alter the method of surface construction, and if the general public would consider the cost of roads in the only real and satisfactory manner, *i. e.*, at per yard supl. instead of at per mile, it would be found even this altered construction in its initial outlay would bear good comparison with the present dust-producing expensive methods.

The road is known as a tarmac road, and costs practically 2s. 6d. per yard supl. to form on top of an old road; it has been proved to last nine years, with practically no cost in material for repairs. Roads that previously have been repaired each year with granite, which at its initial outlay meant 1s. 6d. per yard supl., have been reconstructed with tarmac at a cost of 2s. 6d., and have stood at the present time six winters, with practically no repair.

H. P. Maybury, county surveyor, County of Kent, England. — . . . Whilst tarred macadam roads are excellent for ordinary light motor traffic, the author finds that they do not afford such good foothold for horses, nor are they so solid to support traction engine and heavy motor traffic, as the hard granited and tar-painted surfaces. . . .

For the immediate future the author is of opinion — as the outcome of experiment and experience — that a sure and certain way of improving and fitting the roads for the new traffic is:

(*a*) To build them up as strongly as possible, reducing camber to a uniform 1 in 30.

(*b*) Coat the surface with the best obtainable hard material, broken to a gage of not less than 2 in., and not larger than 2.5 in., well rolled and consolidated, only clean hard gravel and chippings being used as the binding agent.

(*c*) Well clean the surface and apply a dressing of heated tar compound, covering same with hard, clean gravel or granite chippings well rolled with steam roller.

Such a surface is the cheapest to construct, is almost dustless, provides good traveling for traction engines and commercial motors, and is the least slippery for horses. I am by no means satisfied that any other method, even though at double the cost, would be quite as satisfactory for all kinds of users as that set out above.

Clifford Richardson, member American Society Civil Engineers, New York City, U. S. A. — . . . While the experience which has been derived during the last few years from experiments conducted with a view to increasing the resistance of our highways to modern motor traffic points to the fact that surface applications of bituminous materials to macadam roads are only temporarily successful, and that they demand constant renewal and maintenance, it is equally certain that coal tar, when used in the course of construction of the road, as in tar-macadam, while giving greater satisfaction than as a surface application, is not lasting or permanent. It would seem that recourse must be had to the use of a native bitumen or asphalt of a suitable consistency in order to accomplish the result desired. Experiments in America have shown that asphalt, in combination with gravel, where this can be obtained of suitable grading, that is to say, where there is such a combination of fine and coarse material as will result in an aggregate of some stability, offers very considerable hope of success, and that the application of a surface of asphaltic concrete to old macadam roads, where traffic is heavy and maintenance large, would be the most acceptable way of meeting such a problem. . . .

W. J. Taylor, member Institute Civil Engineers, county surveyor of Hampshire, England. — . . . The cost of abandoning the flint, gravel and limestone surface of the 4 500 miles of main roads now coated with those materials in England and Wales and providing them with coats of basalt or granite, would be about 5 000 000 pounds, and can, therefore, only be undertaken gradually. . . .

The financial problem of meeting this wear and tear is one that is occupying the very anxious attention of all road authorities and their engineers in this country. So far there is a general consensus of opinion that as rapidly as funds can be obtained we must abolish from all our more heavily trafficked roads such material as flint, limestone and gravel, and use in their place

the toughest and hardest materials that can be procured, and they must be supported on unyielding foundations. By treating their better surfaces with tar, and by flattening the camber where it is excessive, we find that many of the effects of motor traffic are very largely met. . . .

Final Session of the Congress.

At three o'clock on Saturday, in the amphitheater of the Sorbonne, the members met for the closing deliberations of the Congress. M. Lethier, president general, presided, and on the platform with him sat all of the bureau officials.

One of the first matters considered was a proposition originated by Mr. Logan Waller Page, delegate from the United States, looking toward the establishment of a permanent international commission on road matters. This scheme was elaborated by M. de Timonof, delegate from Russia, and after being framed by the Bureau Général it was presented to the Congress and adopted in the following form:

1. A standing International Road Congress Association is constituted, with a view to furthering road construction, maintenance, traffic and working, as well as to securing in the future the work of this Congress.

2. This association consists of members classified as follows:

(*a*) Delegates of the governments and collectivities of all nations.

(*b*) Members in their own name.

3. A standing international commission is to lead provisorily the association, the commission to consist of the presidents and vice-presidents of the general bureau and of the sectional bureaus of the First International Road Congress held in Paris in 1908.

4. This standing commission is to be managed by a provisory standing bureau sitting in Paris. Each nation is to be represented in this bureau by one or two members of the standing commission. The works of the bureau are to be considered, prepared and carried out by an executive committee sitting in Paris and consisting of three members.

5. The standing commission is entrusted with the laying down of the regulations of the standing International Road Congress Association, and with the immediate enforcement of the same.

6. The standing commission is entrusted with the organization of the next Road Congress, which will be convened in Brussels in 1910.

7. The standing commission is entrusted with considering whether it would be advisable to centralize in a special body the results obtained in the several experiments made in all countries, and to institute further experiments in case of need.

All of the resolutions adapted by the Congress are given below practically verbatim, just as the official translator wrote them. Some of the resolutions are very crude. Most of them seem to be extremely rudimentary and hardly worth while, except for the purpose of recording permanently certain fundamental principles of road construction and maintenance. Certainly there is but little, if anything, in them to which any one can make objection.

First Question: The Present Road.

1. The Congress draws attention to the necessity of constructing the road foundation very carefully with the toughest material; this constituent of the road plays an important part as exerting a considerable influence on the wear and tear of the highway as well as on the upkeep of its profile.

While choosing the foundation system, the structure of the subsoil and that of the road, as well as the character of traffic using the road, are to be taken into account.

2. The Congress is of the opinion that a foundation upon a (4 to 5 in.) 10 to 15 cm. concrete course is especially to be recommended in carrying out paving, even with large paving stones.

In this case the stones are to be laid upon a thin sand cushion.

3. The Congress thinks that it is desirable to continue and to extend the trials made to incorporate tar or bituminous productions into the material of the surface with a view to arrive at some efficient and cheap methods of carrying on the work.

4. The Congress recommends that a binder suited to the nature of the road material and reduced to a minimum should be used while the roller is pressing down the surface.

5. The Congress expresses the desire that the arrangement of the rows of paving stones, either obliquely or perpendicularly to the axis of the road, might be noticed and considered.

6. The Congress expresses the desire that the paving with small stones (*kleinpflaster*), having been reported as giving excellent roads as regards toughness and cheapness, might be tested and considered on roads subjected to various traffic.

Second Question: General Methods of Maintenance.

The Congress considers advisable to keep as closely as possible to the following indications:

1. Macadam roadways.

(*a*) As long as the tests in process will not permit of changing the present methods of maintaining macadam roads, it is recommended that the various services concerned with this maintenance should generalize the complete resurfacing method and limit the partial repairs to the filling up of important holes, principally at the close of the resurfacing period, and above all, during the winter preceding the resurfacing by means of rollers.

(*b*) To use as far as possible only hard and homogeneous road materials, regularly broken; to make choice of a binder suitable to the structure of the road materials used, reducing, moreover, this binder to a minimum.

(*c*) To resurface at once the whole width of the roadway wherever it is possible to turn traffic out of the roadways upon the sideways or adjoining roads, warning boards being placed at the crossings in either direction intimating the carrying out of the resurfacing as well as the road to use for the purpose of avoiding the portion being resurfaced.

(*d*) To continue and undertake with any development which may appear useful the experiments made with surfaces of materials tarred according to various process, or with the use of any kind of binding material, it would be necessary to carefully check the results obtained as regards the cost incurred, sections of length and cross-sections, durability, mud and dust nuisance, intensity of traffic and tonnage, in order to determine the type of roadway which best meets the modern demands and requirements on roads subjected to the heaviest traffic.

2. Paved roads.

(*a*) To use only materials which are entirely homogeneous and perfectly sorted and selected.

(*b*) To use only clean and graveled sand.

(*c*) To keep continually a regular profile by filling up at once any holes and depressions by making the necessary repairs.

(*d*) To undertake a general renewal of paving containing bad faults on the surface and considerable area, when these could not efficiently be met by ordinary repairs, which too often introduce other irregularities into the profile.

(*e*) To grant authority to lay water and gas mains under paved roads only in exceptional cases and for want of any other practical solution.

Third Question: Struggle against Wear and Dust.

1. The Congress recommends the use of suitable paving or other improved surfaces as a remedy for wear and tear, as well as dust, upon roads subjected to traffic heavy in character or in weight.

2. The Congress recommends the development of cleaning, as well as light and frequent watering, by mechanical means.

The use of surfacing such as will facilitate sweeping and removal of mud is also advised.

3. The Congress considers that emulsions of tar or oils, hygroscopic salts, etc. . . . are really efficient, however, unfortunately, for but a short time. Their use, therefore, has had to be limited so far to special circumstances (such as motor races, festivals, etc.); however, it is advisable that trials should be continued with the substances known to-day, as well as with similar products that might later be suggested. Planting of trees along the road is also worthy of encouragement from the point of view of the suppression of dust.

4. (*a*) Concerning the use of tar. The Congress considers that tarring, when well carried out, is undoubtedly an efficient remedy against dust, and that it also, to some extent, protects the roads against the destructive action of vehicles in general and fast motor cars in particular.

(*b*) Use of tar incorporated in the road material. Experiments up to the present date are not sufficient to allow definite judgment to be passed upon the results obtained.

It is desirable that these experiments should be continued, bearing in mind the experience acquired in different countries.

Fourth Question: The Future Road.

1. The Congress considers that where the traffic of self-propelled vehicles is not very great, the present road, if it is constructed and maintained in accordance with the resolutions passed on the first two questions, is satisfactory.

2. (*a*) The carriage way of the road of the future should be homogeneous and composed of materials which are hard, tough, capable of resistance and not slipping.

(*b*) To have but one roadway for every kind of vehicle proportioned to the intensity of traffic, 19 ft. 8 in. (6 m. at least) save in exceptional cases of broad pleasure avenues where several separate roadways are to be recommended.

(*c*) To have the least camber compatible with an easy running off of rain water.

(*d*) To have moderate gradients with as small a difference as possible between the maximum and minimum, it being understood that in exceptional cases gradient may be sacrificed if necessary to avoid sharp curves.

(*e*) The radii of curves should be as great as possible, (164 ft.) 50 m. at least, the curves being connected with the tangents by parabolic arcs.

(*f*) The outside of curves should be slightly raised, but so as not to interfere with ordinary vehicles. No obstructions to the view should be allowed at the curves. A narrow sidewalk bounded by a curb should be laid on the side of the shorter radius, and the depositing of heaps of materials should be forbidden.

(*g*) Intersections of roads should be visible and well opened out.

(*h*) Railway level crossings should be avoided as far as possible, and in all cases should be well opened out and signalled both night and day.

Tramway crossings of roads should also be signalled.

3. The Congress recommends that, wherever they may be needed, tracks for cyclists and paths for horsemen be laid along the roads.

Finally it is desirable that the sides of roads should be clearly defined, as much as possible, by trees.

Fifth Question: Effects of the Means of Locomotion upon Roads.

A. Concerning speed.

1. The circulation of fast motor cars with pneumatic tires causes the disintegration and distribution of the smaller particles of road material.

The greater the speed the more this condition is accentuated, particularly if the road is constructed of badly waterbound macadam, and the materials are not properly bound together, or if the binding is not well incorporated with the final coating and under other conditions generally conducing to the formation of dust.

2. Too sudden an increase in the speed, as well as too sharp an application of the brakes, considerably increases the damage done to the road surface. All changes of speed also do harm, but in less degree.

3. In the curves the action of the centrifugal force is added to the ordinary effects of speed and may considerably increase the damage to the road.

B. Concerning elastic or rigid tires, with or without non-skidding devices.

1. With fast motor cars it is important to reduce as much as possible the damage done to the road by pneumatic tires in using shoes formed exclusively of pliable materials, or at most studded with full rivets, their projections being small compared to their diameter.

2. With heavy motor cars, heavy vehicles or traction engines, the tires of the wheels, if rigid, should be smooth, except in special cases and on certain roads.

C. Concerning the action of weight. The circulation of heavy motor cars upon macadam roads has a tendency to damage the same, principally by causing depressions and ruts.

To avoid this damage, it is important in particular that the pressure per running inch of tire should be moderate in relation to the resistance of the road to shear. A maximum of 825 lb. per in. width of tire seems generally suitable with diameters of wheels being used at present. On the other hand, the absolute axle load is to be considered, as too broad tires cannot exert uniform pressure upon the ground by reason in particular of the camber of the road.

The maximum value of axle load compatible with a sufficient life of the road depends, moreover, both upon the constitution of the latter and the speed of the vehicles.

Sixth Question: Effect of New Methods of Locomotion upon the Roads.

The Congress notices that the same conclusion is always from all points of view, viz., when the condition of some road is unfavorable to automobile traffic for whatever reason, the road itself is injured.

Therefore, if you remove from the road everything which may cause the vehicles to be injured, the latter are no longer an agent of unusual wear and tear of roads, provided that they are kept within limits compatible with the structure of the road considered (either present or future), as regards their speed, the constitution of their tires, their accelerations and their weight.

Seventh Question: Road Signs.

The Congress expresses the desire:

That the system of marking distances may be reorganized as soon as possible according to a general and uniform plan for the whole territory of every country.

That the principle of this organization may be the connection between large centers.

That the indications of distance may begin from the large towns as regards all roads radiating from these points.

That a uniform model for all milestones may be used, and that the inscriptions may be few in number and very legible.

That a uniform method of calculating the distances may be adopted for all towns and regions to facilitate the circulation of cumulative distances.

That steps may be taken to obtain from the several countries the application of identical principles.

That the administrative indications may be limited as much as possible on the board indicating the direction, in order to obtain a larger surface for the inscriptions of direction.

That, from the point of view of the interests of international traffic, a system of warning signals representing the kind of danger and including its name in the national language, should be adopted in all countries interested.

That the number of signals should be limited to four:

1. Obstruction across the road.
2. Corner.
3. Level crossing.
4. Dangerous crossroads.

That danger signals, when they are supplied by private bodies, provided that they have been approved by the authorities and placed in position by them, or under their inspection, should be considered as belonging to the highway and should have the protection of the existing law relating thereto.

Eighth Question: The Road and Services of Mechanical Transport.

1. Automobile vehicles may be advantageously used for public conveyance without injuring the road to any noticeable extent, upon the condition that the average speed does not exceed 18 km. and the maximum speed does not exceed 25 km.; the weight of the driving axle must also be reduced to a strict minimum and the weight of the heaviest axle must be not exceeding four tons when working. The pressure on each centimeter of the width of the wheel rim must not exceed 150 kg. for wheels of the diameter at present in use.

2. Transports for industrial purposes by means of explosion motor lorries may cause no injuries to the road, upon the condition of observing the following limits as regards speed and weight:

The average speed of 10 km. and maximum speed of 15 km.; the weight of the heaviest axle, when working, must not exceed five tons; the driving axle must have metallic tires, with smooth faces to correspond with it.

In all cases the pressure of the tires per centimeter of the width of tire must not exceed 150 kg. for wheels of existing dimensions.

3. It is difficult, in the present condition of the roads and of the automobile industry, to answer the questions arising from the traffic of heavy steam lorries and traction engines. As their use is necessarily limited to a comparatively small extent, it would be useful, in case of need, to fix definite routes on existing roadways.

4. In order to affirm the data and make them more complete, the Congress considers it desirable to collect exact particulars controlled by competent authorities so as to determine the relations to be kept between the constitution of the roadways and the power of resistance of structures connected therewith, and the speed, right width of tires, diameter of wheels, the nature of the tires of the vehicles, the method of suspension of the vehicle bodies, the number of axles, and their distance apart.

5. For the maintenance of the road, as well as for its good working, it is desirable to lay the tracks of light railways outside the bed of the road; at any rate, it is advisable to lay the tracks of these railways and of the tramway lines on special beds, giving to the road a minimum width of 5 m. clear of the railway.

6. When tracks must be laid in the roadway it is desirable that they should be laid at the level of the surface without any projection or depression, without any change of profile, both in the transversal and in the longitudinal direction, and that the roadway should be such that a width of at least 2.60 m. should be provided clear of the portion of the surface on which the tramcars will run; it is recommended that the rail should be provided with a counter-rail, which could be either connected to the rail or be separate.

7. The Congress expresses the desire that tramway authorities may continue in the general interest the researches already carried out with some success, in order to improve the construction and maintenance of the tracks, and especially of the plant laid in the roadway; and that they may discard that which may impede general traffic.

Excursions and Entertainments.

It is not the purpose of the writer to go into a long description of the many entertainments which the French government provided with prodigal liberality for the members of the Congress. Nearly every evening, during the session, some entertainment was provided, and on the several excursions elaborate luncheons, accompanied by the wines of the country, were furnished without cost to the members.

The excursions were so arranged that both the road work and things historic could be seen, and the combination was a very happy one. It is very doubtful if the members of the Congress could have seen so much of Paris and its environs in any other way in so limited a time.

The streets which were inspected by the members in and about Paris were uniformly good, but it has been hinted that some of them had been repaired not long before the inspection. Also that certain other routes leading into Paris which the members were not invited to inspect were in very bad order.

Most of the outlying roads which were inspected had been treated with surface applications of tar, some of them annually for several years. There is no doubt of the efficacy of tar applications under the conditions of climate and traffic which there exist.

In America we have much to learn from the French concerning their treatment of the roadsides. On all the roads which were inspected, the roadsides were in excellent condition, carefully graded and drained, with grass trimmed and free from rubbish and débris. The trees also seem to have been set out most carefully, and appeared to be in perfect condition, with certain exceptions in the Bois de Boulogne, where they have been subjected to much dust in times past. One seems to be riding in a park wherever he goes over the French roads.

Excursion to Nice, Etc.

The final and most elaborate excursion of the Congress was to Nice and its environs. The members to the number of about two hundred and forty left Paris on Sunday, October 18, for Nice, some on the special day train and others on the night train.

On Monday the members visited at will in Nice or rested from the effects of the strenuous activities of the week previous.

The following morning, in automobiles supplied by residents of Nice, the members were conveyed into the heart of the Alpes Maritimes. The objective point was L'Aution, a fortified moun-

tain peak near the Italian border, some 7 000 ft. above the level of the sea. The road follows up the Paillon River for some distance and passes through the villages L'Escarene, Luceran and Peira Cava. The road throughout its entire length is a most interesting example of what the French engineers have accomplished in building their magnificent mountain highways. Were such a road not needed for military purposes the extraordinary expense of such work could not be justified. With an almost perfect surface the road climbs at an average grade of not much less than 6 per cent. for some forty miles up into the mountains, and apparently stops at L'Aution. It abounds throughout in sharp curves with short, straight stretches between them, and in one place, from one position, at least twelve parallel stretches can be counted where the road doubles back and forth to overcome the grade up the mountain. Frequently the road is supported by massive masonry walls, outside of which the mountain side drops away to a depth of a thousand feet or more. The road is exceedingly dangerous at places, for no particular attention has been given to the construction of guard banks or fences.

To climb such a road in a motor car at a speed of more than twelve miles per hour is a most exhilarating adventure. The almost incredible skill of the chauffeurs and the wonderful mechanism of the automobiles in accomplishing the feat were frequently commented upon by all of the Americans present. Public sentiment in America would not permit automobiles to be operated under such conditions, but on the road referred to their use is apparently encouraged. Peira Cava is being advertised and promoted as a winter resort, and to get there easily motor cars are necessary.

Unfortunately at L'Aution the view of the French Alps was obscured by clouds, but at Peira Cava and other lesser heights the prospect was magnificent. In the afternoon the members were driven in the motor cars over more mountain roads similar to those passed over in the forenoon, and equally wonderful in their construction and in the quality of their maintenance, passing by the town of Sospel down into Mentone. The latter place is at the sea level some thirty miles easterly of Nice. From Mentone to Nice the route followed was the lower road near the sea level, and this, although unlike the mountain roads traversed earlier in the day, was an interesting exemplification of French highway engineering. The road passes through Monte Carlo and Monaco, and not until beyond the latter country, for Monaco is a principality of itself, does it present any unusual

difficulty. From Monaco to Nice much of the road was built by cutting into the precipitous ledges which appear to rise directly from the shore of the Mediterranean. Frequently the ledge overhangs the roadway, and in places the road passes through tunnels several hundred feet in length excavated through the solid rock.

The whole day's journey, estimated at about ninety miles in all, could not have been planned better to show the skill of the French road builders. Not only were the locations of the roads admirable from the viewpoint of the highway engineer, but the construction and maintenance problems were equally well worked out. The road surfaces in a number of places show the destructive effect of much use by motor vehicles, and the officials are using tar in such places to hold the road metal together.

On Tuesday, the next day, in the same vehicles, the members were conveyed over the famous road called La Corniche, from Nice to Monte Carlo, passing through La Turbie, the ancient city built by the Romans.

La Corniche, while in some respects more picturesque than the mountain route of the previous day, does not present so many or so difficult problems for the highway engineer. In no place does it attain an elevation greater than two thousand feet above the sea, and its grades are much easier and its curves less sharp. Beautiful views of the Mediterranean are seen at frequent intervals. The same perfection in the details of the roadway was noted here as elsewhere.*

Results of the Congress.

To state the case frankly, after mature deliberation, it does not appear that the Congress added greatly to the knowledge of the world concerning the "ways and means of adapting the roads to the new modes of locomotion."

In this country every state highway commission and many of the local superintendents of highways have been experimenting with bituminous binders of all sorts for several years. There seems to be no doubt that, so far as macadam roads are concerned, such a binder will solve the difficulty.

All of the American delegates, at least, hoped that the European engineers, who have been working for many years with the tar compounds, would shed some light on the subject, but they

* This description of the excursion to Nice, etc., is substantially a reprint from an article by the writer of this paper published in the Boston *Transcript* on November 7, 1908.

French National Road, No. 204 between L'Escarene and Sospel.

View on La Corniche Road.

do not seem to be ready yet to commit themselves. At least they furnished no specifications for bituminous binders which we Americans can use, nor did the resolutions adopted by the Congress.

Getting away from the chemical nomenclature on which the writer is coming to believe the chemists themselves are somewhat mixed, and discarding all reference to hydrocarbons, petroline, asphaltine, ammoniacal liquor, etc., of which no engineer should be expected to have expert knowledge, the problem really is to find some binder of a bituminous nature which, when mixed with the stones of the roadway or grouted or sprayed into the voids between them, will resist the kicking out action of the rear wheels of automobiles operated at high speeds, and which will keep the road surface intact, at a reasonable cost, for, say, ten years or longer.

There are many binders on the market which will accomplish this result, at least for short periods. They are mostly sold under trade names, and all engineers have a distaste for specifying materials under trade names.

The Highway Commission of Massachusetts, feeling that enough has been said about the hydrocarbons, etc., and that too little has been accomplished, and that it can wait no longer for experiments, has asked its chemist to furnish a specification, before the construction season opens, for one or more bituminous binders, and it expects on its future macadam construction to use such binders on a large scale. It seems to be folly to continue to bond state highways with stone dust flushed in by water, when it is absolutely known that such roads will last but a year or two under the new conditions of traffic.

The writer is inclined to the belief that the chief accomplishment of the Congress was the resolution looking toward the establishment of a permanent international commission to collect and distribute information on road matters and to direct experiments and record their results.

The permanent board is to organize at Paris on March 29, and it is expected that it will begin at once upon its labors. Much good should result from the work of the organization, and the Second International Road Congress, which is to be held at Brussels in 1910, will doubtless be much more effective than that of 1908.

[Note. — Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by July 15, 1909, for publication in a subsequent number of the Journal.]

THE SEWERAGE SYSTEM OF SALT LAKE CITY.

By L. H. Krebs, Member Utah Society of Engineers.

[Read before the Society March 19, 1909.]

The subject about which I have been requested to speak to you this evening is one of very great importance to public health, and I shall treat it in a general way, since the time at my disposal will not permit of a detailed description. The field covers such a wide area that minute details must remain to be dealt with at some other time.

Sewers and drains are of very early origin. Among the remains of ancient cities are found the remains of masonry and conduits constructed for drainage purposes. In ancient Rome there remains a great sewer, built in the seventh century B.C., and still in use after the lapse of twenty-five hundred years. With the fall of the Roman Empire, learning and science were almost entirely neglected for a period of one thousand years, until the revival in the fourteenth and fifteenth centuries.

In recent years marvelous advances have been made in engineering and scientific fields, and the evolution of mechanical and constructive processes has been very rapid along the line of modern sanitary engineering, especially as regards sewerage, which has had almost its entire development since 1850. It was not until 1873 that England began to give much attention to the sewerage system, and it was reserved for America to put the system on the road to a satisfactory scientific basis by the investigations of the Massachusetts State Board of Health, begun in 1887 and still in progress. About 1880 the separate system of sewerage came strongly into prominence in this country and it did much to make sewerage possible for small cities.

Statistics have shown in many cities an immediate lowering in the death rates due principally to the construction of sanitary sewers, more than sufficient in money value to pay for the entire cost of the improvement. In line with this, the general statement might be made that pure water supply and good sewerage are both absolutely essential, and it is impossible to separate the value of one from that of the other.

Modern sewerage facilities have become so great a convenience, that it is shown by the increased selling and rental value of premises supplied with a good working system, and no

sooner is a partial or complete system constructed in a town or city, than prospective buyers or renters begin to discriminate against such property not supplied with up-to-date sanitary conveniences, and this is also true with persons looking for new locations for business or residence purposes.

At the present day there are two general systems, the combined and the separate. The combined system is that in which the storm water is conducted into and through the same pipes or conduits with the sanitary sewage. The separate system is generally understood as that in which separate sewers are provided, — one to convey the storm water flow and the other to conduct the sanitary and manufacturing products. Active discussions over the relative merits of these two systems have been conducted by prominent engineers, some advocating one and some the other; but at the present time, the better practice is to use both, adopting that which is best suited to existing conditions and sometimes a combination of the two is used.

On the basis of cost, the separate system is the one better adapted for Salt Lake City, where the sanitary sewage is conveyed in comparatively small pipes and conduits to a safe distance beyond the city limits, while the storm water flow is carried along the street ditches and safely discharged into the nearby watercourses. On account of their relatively small size, the sewers of this separate system are built almost entirely of vitrified sewer pipe, which has the important advantages of greater smoothness, of being impervious, of having few joints and of ease and rapidity with which the pipe can be laid with joints practically water-tight.

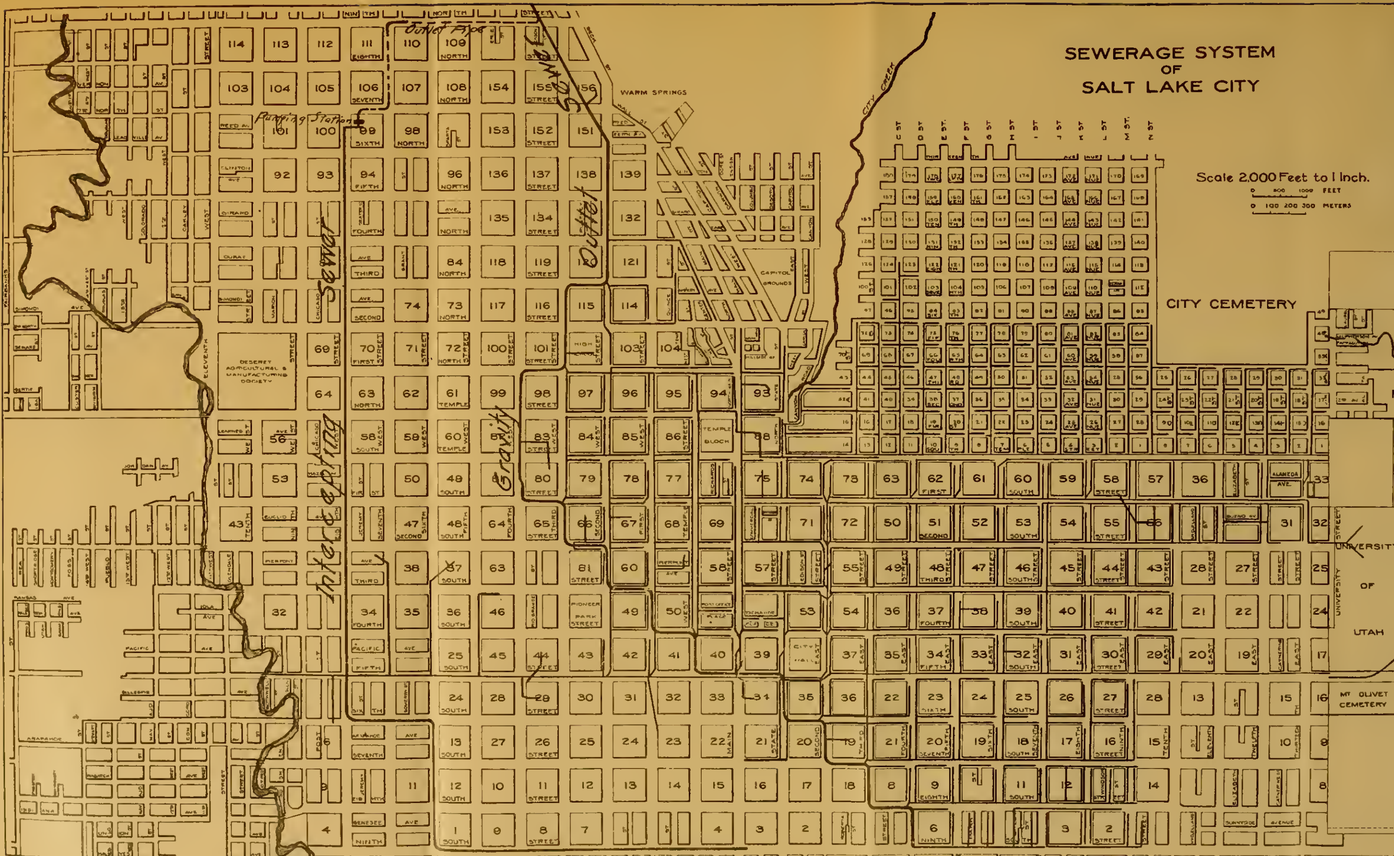
At the same time the smaller, separate system is being flushed more perfectly at less expense with the aid of automatic flush-tanks, of the Miller-Potter type, which are usually built at the end of all sewers. These automatic flush-tanks have been built in this city during the last four years and are of the regular size circular 5-ft. manhole, with concrete walls covered with standard cast-iron perforated cover and are connected with the city water mains by half-inch water pipe. When the water rises to a certain point in the tank, it breaks the air seal in the siphon at the bottom of the flush-tank and the contents of the water in the tank, about 280 gal., rush out through the main trap into the sewer until it is drawn down near the bottom of the bell. Air then enters the bell through a small hole near the bottom, breaking the siphonic action, and the tank immediately begins to fill again, if the water is not shut off.

The man in charge of the flushing department in passing over a district turns on the water in a number of flush-tanks, and by the time he returns to the starting point they have filled and discharged a few times. Then he passes over the same route and shuts off the water again and proceeds to those of another district to be operated in a similar manner. And since the sewerage system at this time is 106 miles in total length, it requires considerable work to keep up a thorough inspection. This is found to be the most convenient, economical and effective method of maintaining the entire system in a clean and satisfactory condition.

A system of hand flushing is also employed in the central part of the city or business district, where the sewers are laid upon such slight grades that the velocity is insufficient to prevent deposits. This method is by the use of sufficient fire hose carried upon hose-reel with four-wheel carriage and horse and two men employed to operate the same. The manhole is provided with a slot in the lower side in which a steel plate is let in by chain and the hose is reeled off and attached to a nearby fire hydrant, when the water is turned on, the manhole is filled, the steel plate withdrawn and the entire contents of water rush out into the sewer and produce the desired results. By the use of this system the district is gone over every week or ten days and the sewer is kept in successful working condition, and it is a very rare occurrence for the department to have to record a complaint directly traceable to sewer gas.

The city is provided with a main gravity outlet sewer and the intercepting sewer, the latter of which is now being put in successful working operation. The main gravity outlet sewer may be described as beginning at Fourth East and Ninth South streets, passing through the streets north and west by blocks, passing the southwest corner of the city and county grounds, thence westerly and northerly, passing on the west side of the Oregon Short Line depot and back to Second West, thence north to Seventh North, whence it takes a northwesterly direction to the outlet at the sewer farm, which is 4.5 miles north and 2 miles west of Salt Lake City base and meridian, the initial point being the southeast corner of the Temple Block.

The first section from Fourth East and Ninth South to Fifth South and State Street is constructed of reinforced concrete with flat top and V-shaped bottom, built in this manner on account of the shallow depth. The remainder to the sewer farm is constructed of concrete and brick, circular sections with a


SEWERAGE SYSTEM
OF
SALT LAKE CITY
Scale 2,000 Feet to 1 Inch.
FEET
METERS
CITY CEMETERY
UNIVERSITY
OF
UTAH
MT OLIVET CEMETERY
WARM SPRINGS
CITY CREEK
CAPITOL GROUNDS
TEMPLE BLOCK
DESERET AGRICULTURAL & MANUFACTURING SOCIETY
PIONEER PARK
Outlet Pipe
Pumping Station
Outlet Sewer
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triple ring of clinker brick in the top. The diameter ranges from 36 to 64 in.

The main gravity outlet sewer carries the flow from all of the lateral sewers that have been laid to the north and east of it, as they have been extended from time to time. The main sewer for the northeast bench begins with 15-in. pipe at South Temple and " B " streets, where it receives the entire flow of all lateral sewers on the northeast bench as far as they are now laid, to Sixth Avenue on the north and Virginia Street on the east. Thence it continues west to Main Street, North Temple, West Temple and First North streets, where it continues directly west and delivers into the gravity outlet sewer at Third West Street. The sizes of pipe are 15, 18, 21 and 24 in.

Main Intercepting Sewer. — The trunk line of this sewer has been designed and constructed for the purpose of conveying all the sewage that may be collected from the gravity outlet sewer to the Jordan River, and it is located in the lowest street between the two.

Beginning with 15-in. pipe at Main Street and Ninth South where it receives the laterals west of the gravity on Fourth East, it runs west to Fourth West, where the size is increased to 18-in. pipe, continues west to Sixth West, thence north to Seventh South, where the size is increased to 30-in. reinforced concrete, circular section, continues north to Sixth South, thence west to Eighth West, thence north to Fifth South, where the size is again increased to 36-in. concrete, continues north to North Temple where it is enlarged to 40-in. concrete and continues north to the pumping station at Seventh North and Eighth West streets. At this point the pumps take up the flow of sewage and force it through a 24-in. wooden stave pipe 4 600 ft. in length, with a total lift of 37.5 ft. and discharge it into the 64-in. section of the gravity outlet sewer at Fourth West and Ninth North streets.

A brief description might be made at this time of the equipment of the pumping-station. The machinery consists of two 12-in. " Byron-Jackson " double suction, horizontal, centrifugal pumps, having a capacity of 4 500 gal. per minute, under a static head of 65 ft. The pumps are stationed at the bottom of the pit and attached to a 12-in. Y, one on each leg, which joins the 24-in. stem just outside the pumping-station. The power to operate pumps is applied through belts and shaft with 150 h.p. electric motor, three phase, operating on 440 volt circuit.

This portion of the installation is completed and in operation, but the suction gas producer is not completed at the present

time. A 200 h.p. triple cylinder gas engine, however, is in place upon the opposite end of the pulley shaft from the electric motor, and in this manner pump No. 1 or No. 2 can be operated by electric motor or gas engine by simply shifting any one of the four friction clutches.

The aim is to install the best economical up-to-date approved plant in the market at the present time, notwithstanding the criticisms of some prominent men of this city that the machinery would not work and could not force the sewage through the 24-in. pipe and raise it 37.5 ft. total lift. One man, when asked to give his opinion, said a stand-pipe should be built to such height and a trestle constructed to permit the sewage to flow into the gravity sewer. Another strong argument was produced, by asking the question, How do you engineers expect to be able to convey the sewage through a 24-in. pipe when the size of the concrete sewer leading into the pumping-station is 40 in.?

Location of Sewers. — Since 132 ft. width of streets of this city is entirely too great to permit of sewers being laid in the center for economical house connections on both sides, it is cheaper and more satisfactory to provide for sewers on each side of all such wide streets. For streets of 82.5 ft., the northeast bench for instance, sewers are located in the center on north and south streets; and on the east and west streets the uniform location is 5 ft. south of the center line for streets without car lines and 15 ft. south of center line for streets having car lines. On all other narrow streets the general location is in the center of the street; exceptionally for some good reason they may be laid 5 ft. south or west of the center.

In some instances where alleys are open, they are used as the cheaper and more desirable location of the sanitary sewers instead of the streets, having the great advantage of avoiding the tearing up of the streets and pavements for sewer repairs and new house connections.

House Connections. — Four-inch Y-junctions are usually located every 25 ft. along the sewer for house connections, but oftener if necessary, and the Y-junction is laid with the slant upward 45 degrees.

Prior to 1908 the city ordinances required cast-iron pipe to be used for all house connections to the sewer, with all joints leaded, which insured a water-tight joint. During last year an ordinance was passed permitting the use of 4-in. vitrified pipe, specifying that all joints be made water-tight. This has proven a very bad ordinance and the experience is that the pipe is

generally laid with open joints; and the result has demonstrated that while the property owner pays a few dollars less for vitrified pipe, he gets a cheap job, with the prospect of having to dig it up in a short time on account of obstructions or broken pipe and also of having a small cesspool at each joint.

Not long since my attention was drawn to an instance where a party requested a plumber to quote a price for making the house connection to the sewer. Seventy-five dollars was given as his estimate for the job, cast-iron pipe to be used. The same party obtained a bid from another plumber, who agreed to do the work for $72.00, just $3.00 less, and was given the contract. Vitrified pipe was laid and the party was none the wiser.

The city ordinances make the city engineer *ex-officio* supervisor of the entire system including the construction, control and recording of house connections, and it is his duty to set stakes for all pipes laid from the sewer to all buildings in order that no sags or traps shall exist in the pipe line, and that the grade shall be uniform and none permitted less than one foot in sixty, and the inspection rests with the plumbing inspector.

All necessary measurements are taken at the time the building is being connected with the sewer and all clean-outs located. These notes are first platted upon large record books in the city engineer's office and the loose leaves are bound in book form for future use and reference. The nominal charge of one dollar is made for each house and two dollars for the actual cost of engineering work done. The method employed in this city for keeping the exact record of all house connections and the system of files in the office have been complimented by many as among the best in the United States for the protection of the property owner, to which he and the public generally are entitled.

Before closing, a few remarks, which may be of interest to you, might be made upon the laws under which public improvements of this class can be obtained. The property owners of a district, desiring to have the sewers extended for the benefit of their property, send a petition to the City Council for said improvement. Upon the granting of the request by resolution, the city recorder is instructed to advertise notice of intention; but before this can be done the profiles must be made by the city engineer, elevations of all existing basements secured and platted, so that grade lines can be laid and the quantities figured for the approximate estimate of cost to be published in the notice of intention.

The notice being published for a period of twenty days, gives

the property owners a date upon which all protests must be filed. And the law further provides that protestants must represent more than two thirds of the entire frontage of abutting property in order to defeat the improvement. One third or more favorable to said extension will carry the same.

When the City Council confirms the ordinance of the district to be benefited, the Board of Public Works is instructed to advertise notice to contractors for bids, and upon the letting of a contract the actual cost of said sewer extension is figured, and the total cost divided by the total front feet of abutting property gives the cost per front foot.

The law passed by the legislature of 1908 provides that after five blocks of sewer are constructed, the first partial estimate is made up for the contractor, and after its approval by the City Council the ordinance covering said five blocks is published twenty days, confirmed, and then the tax levy is made and notices sent by the City Treasurer to the property owners, stating the front feet, rate and amount of said tax and also the date when first payment becomes due. The law also provides that said tax may be paid in five annual payments after the first, with 6 per cent. interest and 8 per cent. on all deferred payments.

There should be a law providing for condemnation of a right of way for the extension of a lateral sewer into and through private courts or narrow streets which have not been accepted by the city as public streets.

The sewerage system should be carefully maintained in good condition. It is a mistake to think that when a system is completed no further attention is necessary; and I must say that many people have a mistaken idea of the grades of our sewerage system and think that almost anything can be forced into and through the sewer no matter what it is.

Our system, as previously mentioned, is the separate system, and the principal reason for perfecting the design in this manner is the flat condition of the city in all directions beyond the foot of the steeper slopes. The main gravity outlet sewer has a grade of but 2.4 ft. per mile, with a velocity of 2.5 ft. per second; and the section is circular for this kind of sewer. The larger egg-shaped sizes are generally used for the combined system, and the purpose of this shape is to keep the sewer washed out when the storm water flow begins to diminish. The grades are usually very much heavier.

It will not do to turn the washings of our streets into the sewer, or any other surface drainage; and the general public

should take special pride in reporting to the engineering department any violations of the city ordinances, which provide that it is a misdemeanor to even remove a cover from a manhole, for which a fine, or imprisonment, or both is provided.

The whole system may become a source of danger to the public health, instead of a means of safety, unless it is given proper care and attention, and I will close with the scriptural quotation, " All that a man hath will he give for his life."

[NOTE. — Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by July 15, 1909, for publication in a subsequent number of the JOURNAL.]

DISCUSSION OF PAPER BY JOSEPH H. HARPER, "HYDRAULIC TABLES."

(Vol. XLII, Page 74, February, 1909.)

Mr. M. L. Holman. — The formula of Ganguillet and Kutter, as developed by the authors, in metric units is:

$$V = \frac{23 + \frac{0.00155}{i} + \frac{1}{n}}{1 + \left(23 + \frac{0.00155}{i}\right)\frac{n}{\sqrt{r}}} \sqrt{ri}.$$

This formula or its English equivalent, may be written as follows:

$$V = \frac{41.6 + \frac{0.00281}{i} + \frac{1.811}{n}}{1 + \left(41.6 + \frac{0.00281}{i}\right)\frac{n}{\sqrt{r}}} \sqrt{ri} = \frac{Z}{1 + \frac{X}{\sqrt{r}}} \sqrt{ri}$$

in which Z and X are functions of the slope and the coefficient of roughness.

For convenience of application a table of values of Z and X may be computed and the work of applying the formula simplified and reduced. This is the method generally given in engineers' note-books published in Germany and France.

The following tables, computed by the writer, give a sufficient number of values of Z and X for field work. These tables and a 10-inch slide rule are all that is necessary for solving the Kutter formula. For that matter, if one can handle the slide rule the tables are not necessary.

Values of Z and X for Kutter Formula. Metric Units.

Slope	.0001		.001		.010		.10 to 1.0	
n	Z	X	Z	X	Z	X	Z	X
.010	138.5	.385	124.6	.246	123.2	.232	123.0	.230
.011	129.4	.424	115.5	.270	114.1	.255	113.9	.253
.012	121.8	.462	107.9	.295	106.5	.278	106.3	.276
.013	115.4	.501	101.5	.319	100.1	.301	99.9	.299
.014	109.9	.539	96.0	.344	94.6	.324	94.4	.322
.015	105.2	.578	91.2	.368	89.8	.347	89.7	.345
.016	101.0	.616	87.1	.393	85.7	.370	85.5	.368
.017	97.3	.655	83.4	.417	82.0	.394	81.8	.391
.018	94.1	.693	80.1	.442	78.7	.417	78.6	.414
.019	91.1	.732	77.2	.466	75.8	.440	75.6	.437
.020	88.5	.770	74.6	.491	73.2	.463	73.0	.460

Values of Z and X for Kutter Formula. English Units.

Slope	.0001		.001		.01		.10 to 1.0	
n	Z	X	Z	X	Z	X	Z	X
.010	251	0.697	226	.444	223	.419	222	.416
.011	234	0.767	209	.489	207	.461	206	.458
.012	220	0.836	195	.533	193	.503	193	.500
.013	209	0.906	184	.577	181	.544	181	.541
.014	199	0.976	174	.622	171	.586	171	.583
.015	191	1.05	165	.666	163	.628	162	.625
.016	183	1.12	158	.711	155	.670	155	.666
.017	176	1.18	151	.755	148	.712	148	.708
.018	170	1.25	145	.799	143	.754	142	.749
.019	165	1.32	140	.844	137	.796	137	.791
.020	160	1.39	135	.888	132	.838	132	.833

OBITUARY.

Timothy Guiney.

Member Boston Society of Civil Engineers.

Timothy Guiney, son of Cornelius and Julia (Mahoney) Guiney, was born in Boston, Mass., on August 27, 1879. He received his early education in the public schools of Boston, and was graduated from the English High School in 1896, taking a post-graduate course in the following year.

His first work after leaving school was as clerk with a wholesale drug company, where he remained until the year 1900. He was next employed as sub-foreman on underground construction with the New England Telephone and Telegraph Company. In June, 1905, he accepted a position with the Metropolitan Park Commission, where he was employed as rodman, principally on topographical and preliminary surveys, continuing there until May, 1906, when he was transferred to work with the Charles River Basin Commission. With the latter commission he was advanced to the grade of instrumentman, having charge of lines and grades for the construction of two sections of the Boston Marginal Conduit and the Boston Embankment. His notes and records are models of accuracy and neatness and his work was done with thoroughness of detail and good judgment.

In June, 1907, he was graduated from the mechanical engineering course of the School for Industrial Foremen, and last fall began taking a course in English literature, both being evening courses of the Lowell Institute. He had successfully passed, with high marks, the civil service examinations for the position of assistant engineer in the service of the Commonwealth of Massachusetts and that of leveler in the state of New York. He became a member of the Boston Society of Civil Engineers on April 15, 1908.

Mr. Guiney was an exemplary young man, and we cannot speak too highly of his characteristics. He was very studious, ever trying to improve himself as will be noted from the fact that he had qualified for advancement under the civil service and during evenings he had studied and attended school.

He was an independent thinker, a good analyst and remarkably well read. He was of a modest and retiring dis-

position, and his ability and trustworthiness were only known to his near associates, with whom his memory will ever live.

Mr. Guiney had a weak heart, caused by its being about two inches out of its normal position. His doctor said that it was phenomenal that he should have lived as long as he did. Very few of his friends realized his condition, as he seldom spoke of his infirmity. The end came very suddenly. He passed away without warning, on his way to luncheon, at noon of Thursday, February 4, 1909. He was not married. His parents, two sisters and two brothers survive him.

J. L. Howard,
John N. Ferguson,
Committee.

ASSOCIATION

OF

ENGINEERING SOCIETIES.

Organized 1881.

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RAILROAD TERMINAL IMPROVEMENTS AT PROVIDENCE, R. I.

BY GEORGE B. FRANCIS, MEMBER BOSTON SOCIETY OF CIVIL ENGINEERS.

[Presented to the Society, March 17, 1909.]

THE opening of the East Side tunnel in Providence, in the latter part of November, 1908, and the transferring of the service of the Providence, Warren & Bristol Railroad from India Point Station to the Union Passenger Station, marked the completion of the general scheme of railroad terminal improvements and makes possible the preparation of a complete history and description of the union terminal station problem developments which have been going on for the past ten years. Practically no complete account of this terminal, as finally built, has ever been published, though various features of the works have been described from time to time, during construction, in the daily local press and current technical journals. It is hoped, therefore, that the subject-matter may be of some interest and use, if only collating in one paper information hitherto scattered through many publications.

The station has been operated (exclusive of the Providence, Warren & Bristol Railroad) for over ten years, and although the train service has largely increased during that period, no important changes in the layout have been made, showing the care and foresight with which the details of the problem were thought out. The facilities provided are not only ample for present needs, but, it may be confidently predicted, will be found sufficient, with the same ratio of increase, at the end of another decade.

This paper, which relates to the history and construction prior to the entrance of the Providence, Warren & Bristol Rail-

road, has been prepared by Mr. Francis; and the succeeding paper relating to the construction of the tunnel and its approaches has been prepared by Mr. Dawley.

The authors are specially indebted to Carlton E. Hunt, formerly of Providence, and associated with both the writers on engineering matters for the past twenty years, for assistance in collecting and collating the historical and descriptive information.

General History.

To understand aright the problem of improved railroad terminal facilities at Providence, R. I., some account of the early general history of the various roads, and a statement of the peculiar local conditions are necessary.

"In the early years of the preceding century there was in the outskirts of Providence a stretch of marshy land and a sheet of water where the Woonasquatucket and Moshassuck rivers unite and form the Providence River. This place (the water in which was subject to tide range) was known as the Cove." *

As the city grew and needs for better railroad facilities increased, grants were sought and obtained by the various roads to fill and use portions of this cove area for railroad purposes, so that in time and in conformity to a well-defined plan adopted by the city, "combining the advantages of preserving the beauty and utility of the Cove; of procuring open land near the center of the city for the use of the public and of affording convenient locations for the depots of such railroads as are expected to terminate at this city," a large basin, elliptical in form, and comprising an area of about 25 acres, was established, and a small strip of land, 80 to 100 ft. in width, surrounding the same was laid out as a public park.

"The termini of the first railroads built into Providence were, however, remote from this center, and were located at points on the harbor on the southerly side of the city skirting the easterly and southerly sides of the population, as it then existed." †

"This location seems to have been selected from the first by the projectors of the road between Providence and Boston as the southerly terminus, presumably for the purpose of making the most feasible connection by steamer with New York," † and

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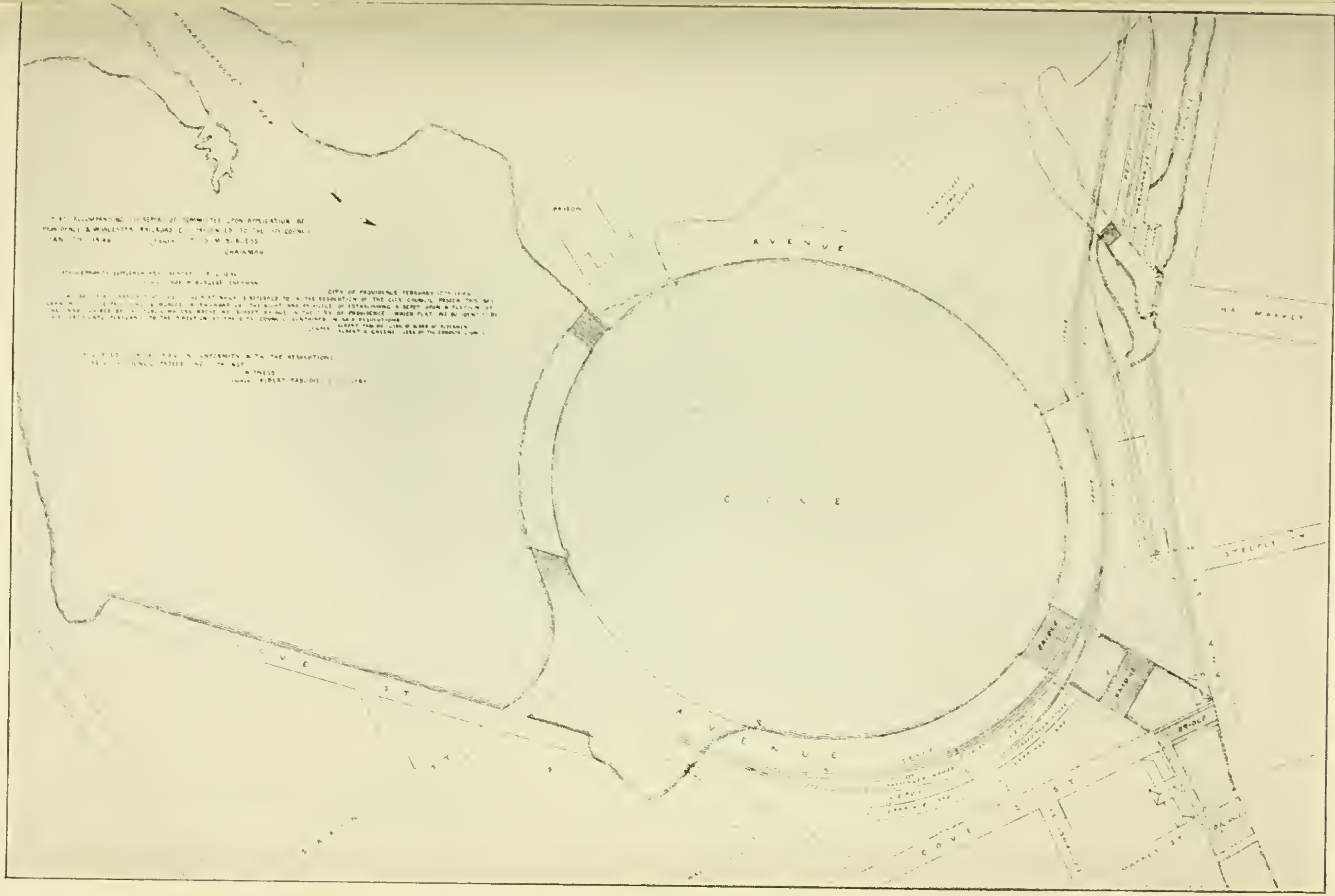
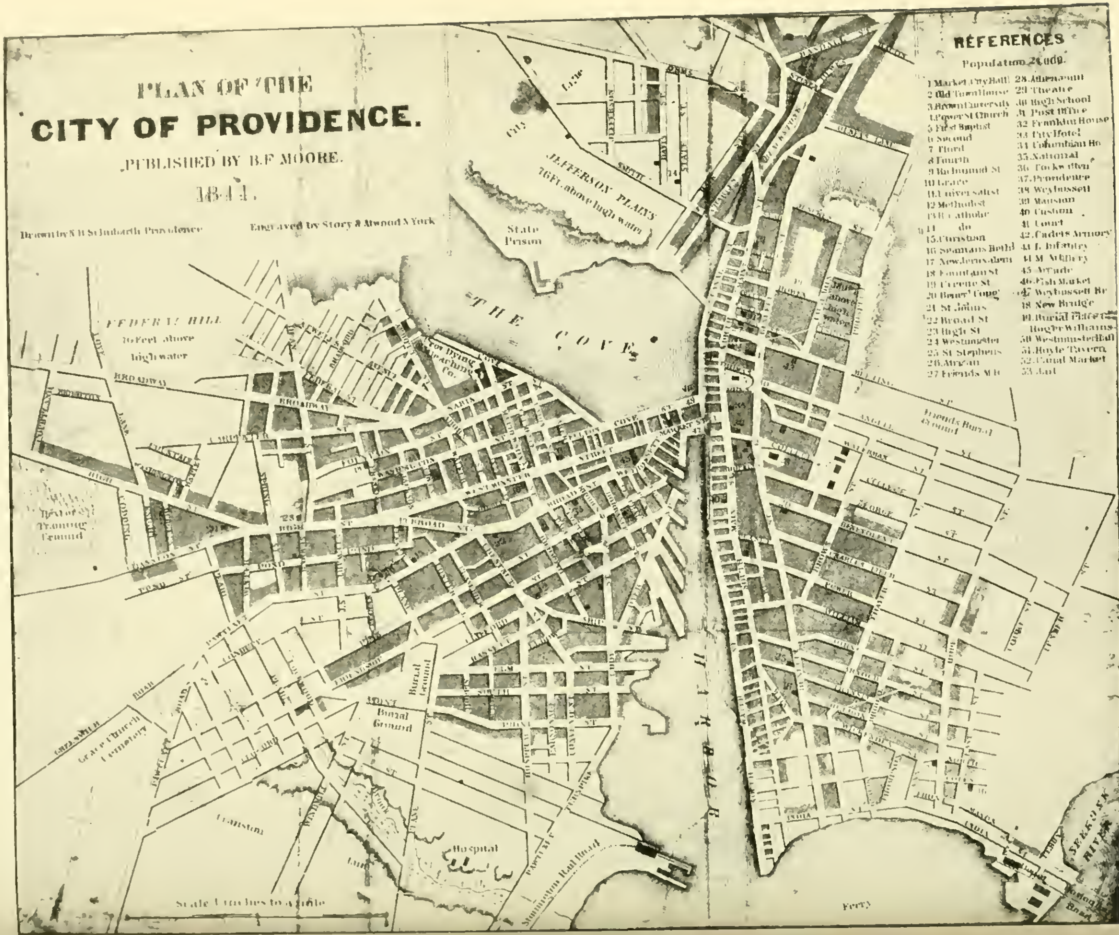
* *Engineering News*, January 28, 1897.

† Minot: "Railroad Terminal Facilities in Providence," Journal of the Association of Engineering Societies, November, 1890.


AVENUE
COVE
PRISON


PLAN OF THE
CITY OF PROVIDENCE.
PUBLISHED BY B.F. MOORE.
1844.
Engraved by Story & Atwood N York
REFERENCES
1 Market City Hall
2 Old Town House
3 Brown University
5 First Baptist
6 Second
7 Third
8 Fourth
9 Richmond St
10 Grace
11 Universalist
12 Methodist
13 R Catholic
14 do
15 Christian
16 Seamans Bethl
17 New Jerusalem
18 Fountain St
19 Greene St
21 St Johns
22 Broad St
23 High St
24 Westminster
25 St Stephens
26 African
27 Friends M H
28 Athenaeum
29 Theatre
30 High School
31 Post Office
32 Franklin House
33 City Hotel
34 Columbian Ho
35 National
37 Providence
38 Weybosset
39 Mansion
40 Custom
41 Court
42 Cadets Armory
43 L Infantry
44 M Artillery
45 Arcade
46 Fish Market
47 Weybosset Br
48 New Bridge
49 Burial Place of Roger Williams
50 Westminster Hall
51 Hoyle Tavern
52 Canal Market
53 Jail
JEFFERSON PLAINS
76 Ft. above high water
State Prison
THE COVE
FEDERAL HILL
70 Feet above high water
HARBOR
SEEKONK RIVER
Friends Burial Ground
Burial Ground
Hospital
Cranston
Ferry
Stonington Rail Road
Scale 3 inches to a mile

it was the natural location of the terminus of the line built a year or two later from Stonington. "In the light of present conditions it would seem that a mistake was made. Had the directors realized the importance of developing local business, which threatened competition later made plain, or had they in any way considered, what they learned later, that it was necessary to enter Providence from the north,"* the original line would have been selected following more nearly the present traveled way.

The following is a brief account of the various railroads entering the city, giving dates of incorporation, construction, development and final consolidation by lease or merger into one operating company.

Boston and Providence Railroad.

Charter for this road was obtained July 11, 1831, and in August of the same year Wm. Gibbs McNeil, captain of United States Engineers, was engaged by the Board of Directors of the corporation for the purpose of determining generally the circumstances under which a railroad could be constructed between the cities of Boston and Providence.

A report was submitted in April of the following year and was accompanied by maps, profiles and estimates for several routes surveyed, all of which terminated at India Point in the city of Providence, where connection was afforded by steamer with New York.

The construction of the road was begun in 1832 and completed in three years, being opened from Boston to Providence in August, 1835.

The road as located under the Massachusetts charter ended near the east end of India Bridge, the state line at that time being the easterly shore of Seekonk River.

In May, 1834, the Rhode Island legislature chartered the Boston and Providence Transportation Company, authorized to connect with the railroad then being constructed from Boston, to build a bridge across Seekonk River, passing into the state of Rhode Island to tide water in the city of Providence and to build wharves, docks, basins, warehouses, depots, etc.

In March, 1846, a charter was obtained for a branch road, which was immediately built from a point south of Dodgeville, on the main line, to the state line, in the direction of Central

* Minot: "Railroad Terminal Facilities in Providence," JOURNAL OF THE ASSOCIATION OF ENGINEERING SOCIETIES, November, 1890.

Falls. This line was constructed to meet the threatened competition of an opposition road then being built between Attleboro and Pawtucket, and was the first move toward the location of a line from Boston entering Providence from the north, which was eventually to become the main route for this class of traffic.

In the same charter authority was granted to make a connection with the Providence & Worcester Railroad in Rhode Island, and to purchase depot accommodations in the city of Providence. Under this authority a joint ownership with the Worcester road was secured of the location from the junction at Central Falls to the city of Providence and of portions of the terminal station and grounds.

The road was leased to the Old Colony Railroad for ninety-nine years on April 11, 1888, which latter company, in its turn, passed into the control of the New York, New Haven & Hartford Railroad in 1893.

New York, Providence & Boston Railroad.

In 1832, the year following the incorporation of the Boston & Providence road, parties in Rhode Island, Connecticut and New York secured charters from the first two named states for the New York, Providence & Boston Railroad, which was built from Providence to Stonington, where connection by steamer was made with New York. The road was built under direction of Wm. Gibbs McNeil and opened in November, 1837.

As in the case of the Boston & Providence road, its Providence terminus was far from the present location, being situated on the Providence River, at a point opposite Fox Point, a most natural one, in those early days, in view of the desired connection by ferry with the road to Boston, the line being designed as part of a through route from Boston to New York.

At the October session, A. D. 1846, the Rhode Island General Assembly granted charter for an extension of the line from Auburn, about six miles from Providence, known as the Olneyville Branch, thence to and upon the Cove in the city of Providence, in such a manner as would enable it to make a connection with either the Providence & Worcester Railroad or the Boston & Providence Railroad. This line was completed in 1848.

On May 1, 1888, the road secured control by a ninety-nine years lease of the Providence & Worcester Road, with its valuable eastern outlet. In March, 1892, the road was leased to the New York, New Haven & Hartford Railroad, which lease was terminated a short time later and the properties merged.

Providence & Worcester Railroad.

This road was incorporated by the Rhode Island General Assembly at its May session, 1844, and the work of construction of the road from Worcester to Providence undertaken immediately thereafter.

On February 17, 1846, the city of Providence, empowered by an act of the General Assembly of the preceding year, granted the right and privilege to construct a depot on portion of the land covered by public waters, provided the railroad filled certain portions of the land and built walls, bridges, etc. The location of this station, which was built in 1847–48, was on Exchange Place and was used jointly with the Boston & Providence Road, which built and owned the westerly portion.

The operation of the road passed into the hands of the New York, Providence & Boston Railroad by a ninety-nine year lease, dated May 1, 1888.

When the New York, Providence & Boston Railroad was merged with the New York, New Haven & Hartford Railroad the lease of the Providence & Worcester Railroad to the former company was canceled by vote of the stockholders on January 7, 1893, and ratified with the latter company on the same date, to take effect from July 1, 1892.

Hartford, Providence & Fishkill Railroad.

This road was formed by the union of the Providence & Plainfield Railroad, incorporated by the Rhode Island Legislature in 1846, with the Hartford, Providence & Fishkill Railroad, incorporated by the Connecticut Legislature.

"In 1849 the legislature of Connecticut granted the New York & Hartford Railroad Company and the Hartford, Providence & Fishkill Railroad Company permission to consolidate as the Hartford, Providence & Fishkill Railroad, and in 1852 the Providence & Plainfield Company was merged into this union, which operated the road between Providence and Waterbury, Conn. August, 1863, an agreement was made between the Boston, Hartford & Erie Railroad Company, chartered by Connecticut in July of the same year, and the Hartford, Providence & Fishkill Company, conveying the road owned by the latter to the former company both by deed and by lease for nine hundred and ninety-nine years. This company, the Boston, Hartford & Erie, was dissolved in 1873 by a decree of the Connecticut courts and the

New York & New England Railroad Company obtained possession of the road." *

Providence & Springfield Railroad.

This road was chartered in 1857 under the name of the Woonasquatucket Railroad Company, which was changed to Providence & Springfield Railroad Company in 1871. The original plan was to build a line between Providence and Springfield and by connection with the Boston & Albany Railroad at the latter point offer a new and more direct line to the West.

In 1873, the road was completed and put in operation from Pascoag, R. I., to a connection with the Hartford, Providence & Fishkill Railroad at Dyke Street, Olneyville. The road then desiring to gain approach to the city of Providence for terminal purposes, arranged with the Hartford, Providence & Fishkill Railroad and the city for the right to lay track and operate trains upon the same over the roadbed of the latter railroad company. Its eastern terminus was thus changed from Olneyville to a point near the business center of Providence, a station being erected on the Cove lands just west of Gaspee Street.

On October 1, 1890, the New York & New England Railroad secured control of this property by a ninety-nine year lease.

New York & New England Railroad.

" This road was itself the reorganized successor of the Boston, Hartford & Erie Railroad, which latter company was the composite result of a merger by consolidation or purchase of a very considerable number of smaller railroad companies, which had sustained a more or less precarious existence in Massachusetts, Rhode Island, Connecticut and New York. This company owed its corporate existence to a charter granted by the state of Connecticut in 1863," † and it was adopted and declared to be a Rhode Island corporation on April 17, 1873.

Entrance into Providence from the west was secured by its control of the Providence, Hartford & Fishkill Railroad and from the east by control of the Rhode Island & Massachusetts Railroad, which it leased on October 1, 1887, for a term of ninety-nine years. This latter company had entrance into the city from Valley Falls by agreement with the Providence & Worcester Railroad.

* " Providence Plantations," page 138.

† Massachusetts Railroad Commission Report, 1895, p. 27.

On October 1, 1890, it leased the Providence & Springfield Railroad and thus controlled with the New York, Providence & Boston Railroad the only entrance into the city from the west. The road passed into receivers' hands on December 28, 1893, and was reorganized about a year later under the name of

The New England Railroad.

This was accomplished by means of a foreclosure sale under the second mortgage of the former company, and the incorporation of the purchasers and their associates under the new title. The organization was effected August 26, 1895, and the management of the road passed from the hands of the receivers into those of the new company on September 1, 1895. The actual control of this new company was in the hands of the New York, New Haven & Hartford Railroad, by virtue of the ownership of a majority of the shares of capital stock.

On May 10, 1898, a lease was signed to the New York, New Haven & Hartford Railroad for a period of ninety-nine years from July 1, 1898; this lease was subsequently abrogated and the properties merged as of April 1, 1908.

Providence, Warren & Bristol Railroad.

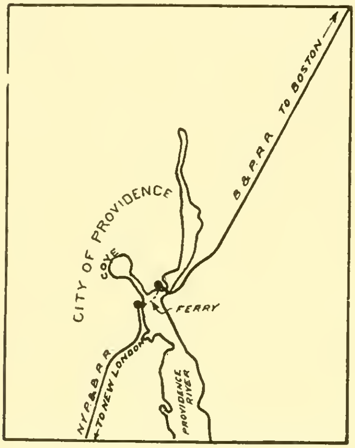
This road was incorporated by the Rhode Island Legislature in October, 1850, under the name of the Providence & Bristol Railroad Company, which was changed to the Providence, Warren & Bristol Railroad Company in 1852. It was built from Bristol to Providence, with terminal at the latter place located on the south side of the city at India Street, and was opened for traffic in January, 1855.

On July 1, 1891, the control of the property passed to the Old Colony Railroad by lease for ninety-six years.

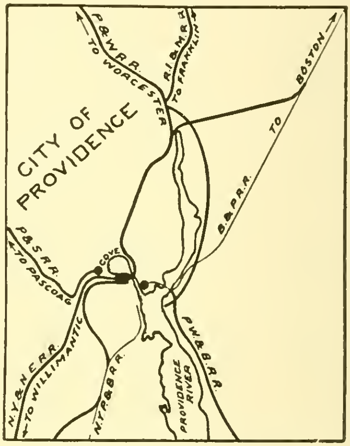
History of the Agitation.

The agitation of improved railroad terminal facilities in Providence, which for so many years proved such a vexed question to both citizens and engineers alike, had its inception with the appointment of the Doyle Commission in 1873, and was augmented and prolonged by the difficult and at times almost hopeless task of harmonizing the conflicting interests of citizens, municipal authorities and the several independent railroads. At the time the agitation began the railroad situation was about as follows:

The original termini of the two roads first to enter the city, i. e., from Boston on the east and Stonington on the west, had long been abandoned for passenger service for a union station located nearer the center of the city. This original Union Station for a time consisted really of two separate head houses, it being contemplated that there should be an open driveway through to



ORIGINAL STATIONS IN PROVIDENCE
1837



STATIONS IN PROVIDENCE
1890

the Cove promenade. The danger from frequent passing of trains, however, resulted in the final abandonment of this street and the buildings were subsequently joined, the space being used for a restaurant, news depot, etc., on the first floor, with offices and trainmen's quarters above. The easterly portion of the station was owned by the Providence & Worcester Railroad Company, and the westerly portion was the property of the Boston & Providence Railroad Company, while the central portion with the land contiguous in the rear was joint property. The New York, Providence & Boston Railroad, and later the Hartford, Providence & Fishkill Railroad, had accommodations in the westerly and the New York & New England Railroad in the easterly building. The terminal of the Providence & Springfield Railroad, which was originally at Olneyville, had been moved to Gaspee Street, about one half a mile to the west of the Union Station, and that of the Providence, Warren & Bristol Railroad was in another part of the city, about a mile to the south, near Fox Point.

With the growth of the city and the increase of railroad traffic, the question of better terminal facilities became one of

prime importance. The freight business of all the roads centering in Providence was hampered by lack of adequate facilities both as regards commodious buildings and yard room, and the trouble was augmented year by year until it threatened to work serious results to the business interests of both city and state.

A solution of the problem, which would afford consolidation of all the various roads in one terminal station building, with proper and adequate facilities for the reception, transfer and prompt delivery of freight, was begun in 1873, and precipitated a discussion which lasted through about twenty years, resulting in the presentation of nearly as many different plans.

All of the plans brought forward might be gathered up into four groups, and, although many variations, radical in their differences, were suggested for developing the dominant idea of each, they may be classified as follows:

1. Stub-end *v.* through stations.

2. Present site *v.* new site.

3. Cove preserved for park *v.* cove filled for railroad purposes.

4. Elevated *v.* surface stations.

Stub-end v. Through Stations.

The earlier plans presented favored a stub-end station. It had long been the ambition of many of Providence's ablest and most public spirited citizens to establish her place as a great distributing center for New England, arguing that this was not without warrant in view of the many advantages accruing from her favorable location and the transportation demands of her established industries. Situated at the head of Narragansett Bay; possessed of excellent tide water facilities; the terminus of six independent railroads; the center of a large and growing manufacturing district whose industries called for a large amount of coastwise and foreign shipments, first of the raw material and then of the finished product, it was hoped that she might attain a long lead as the second city of New England and one of its chief ports of entry.

Those who caught this vision of the city's future possibilities labored zealously, if not too wisely, for its realization. When, therefore, the time came for developing the terminal facilities of the various independent railroads within her boundaries, that any plan would tend to make the joint terminal a way station was deemed sufficient reason for discarding it as inimical to her

future welfare. So strong was this feeling that it is believed to have been one of the potent factors in defeating the plans presented by the Goddard Commission in the early 80's.

The plan for a through station was the result of more mature study of the problem, and its favorable consideration was augmented by the growing spirit of consolidation and the advantages accruing from better facilities for interchange of traffic.

The plan finally adopted was really a compromise, embracing the essential features of both of these types.

Present Site v. *New Site.*

To the Goddard Commission is largely due the credit for settlement of the vexed question of location for the proposed new union station.

"The Commission, though slow to decide a question of such vital importance without the most deliberate investigation, were unanimous in the opinion that the abandonment of the existing site for a distant or inaccessible one would be a fatal error in judgment."[1] Public hearings were given by them, which, due to the general interest in the subject, were well attended; expert advice from many sources was sought and carefully considered and the consensus of opinion of citizens, merchants, engineers and the railroads was favorable to the retention substantially of the present site.

Discussion developed the fact that the lands held by the railroads entering the city from the north, obtained as grants by legislative enactments or acquired by "right of eminent domain," could not be taken from them without legislative action, nor for other than public purposes, and the railroads were unwilling to renounce so valuable a franchise to accept a location which, they considered, would prove a serious detriment to the developing of their growing suburban business; and the city was not willing to incur the expense of acquiring so valuable a property for a public park.

Several years later, when the Experts' Plan appeared, locating the station on the north side of the Cove, it met a storm of protest from both merchants and railroads.

Cove Preserved for Park v. *Cove Filled for Railroad Purposes.*

Opposition to filling the Cove basin seemed to come from two sources, viz., a few property owners on Smith's Hill and the Public Park Association. Many arguments were brought

forward to show not only the desirability and financial advantages of a public park in the business center of the city, but the disaster that would result from filling the basin. It was asserted "that as a storage place for water, this cove basin was essential to the safety of the city in case of freshets," or southerly gales, which would back up the flood-tide waters in the narrow river channel; that the filling of the cove basin would give tides about 2 ft. higher in the harbor and channel of the rivers than with the Cove open; that this would mean practically lowering the grade of all streets on the water front 2 ft.; that it would destroy the harbor to Fox Point and greatly lessen the sanitary value of the Cove park and that it would entirely destroy the current in the river to Fox Point.

"Preliminary investigation satisfied the Goddard Commission that the opposition to filling the Cove was very limited and that the great body of citizens desired that this area should be filled and devoted to railroad purposes, for which it is so manifestly adapted by its natural conformation. They also became convinced that the Cove basin, in its present condition, exerted no appreciable influence upon the harbor and cannot be considered as essential to the preservation of the public health." *

Six years elapsed, however, before any move was made by the city to build the necessary river walls and fill the Cove basin.

Elevated v. *Surface Station.*

One of the essential requirements of any plan that would prove acceptable to either city or railroads was the abolition of all grade crossings, but the question of whether the streets should be carried over the tracks, or the tracks over the streets, was not so easily settled, involving, as the location did, the fundamental character of the layout, i. e., surface or elevated.

The existing station site, which was very generally accepted as the proper one for the new station, was in a valley, with descending grades in both directions, and lay only four or five feet above tide water, so that it was impossible to carry the streets under the tracks without raising the latter.

Both the Goddard Commission and the railroads had worked out plans for elevated and surface stations, and the problem received the most careful engineering study and the fullest and most public discussion.

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* Report of Commission on Railroad Terminal Facilities, 1882, City Documents, 14.

The objectors to the elevated layout claimed that the necessary construction of high walled embankments would bisect the city, cutting off the northern portion from the business center and prove a decided detriment to the property and the manufacturing interests of that section. An elaborate profile was prepared, whose distorted proportions gave to the lay mind a decided misconception of the real height of the embankments, which were termed "Chinese walls," and the openings for streets through the same were characterized as "rat holes." It took eight years of patient and persistent educational methods to overcome this prejudice.

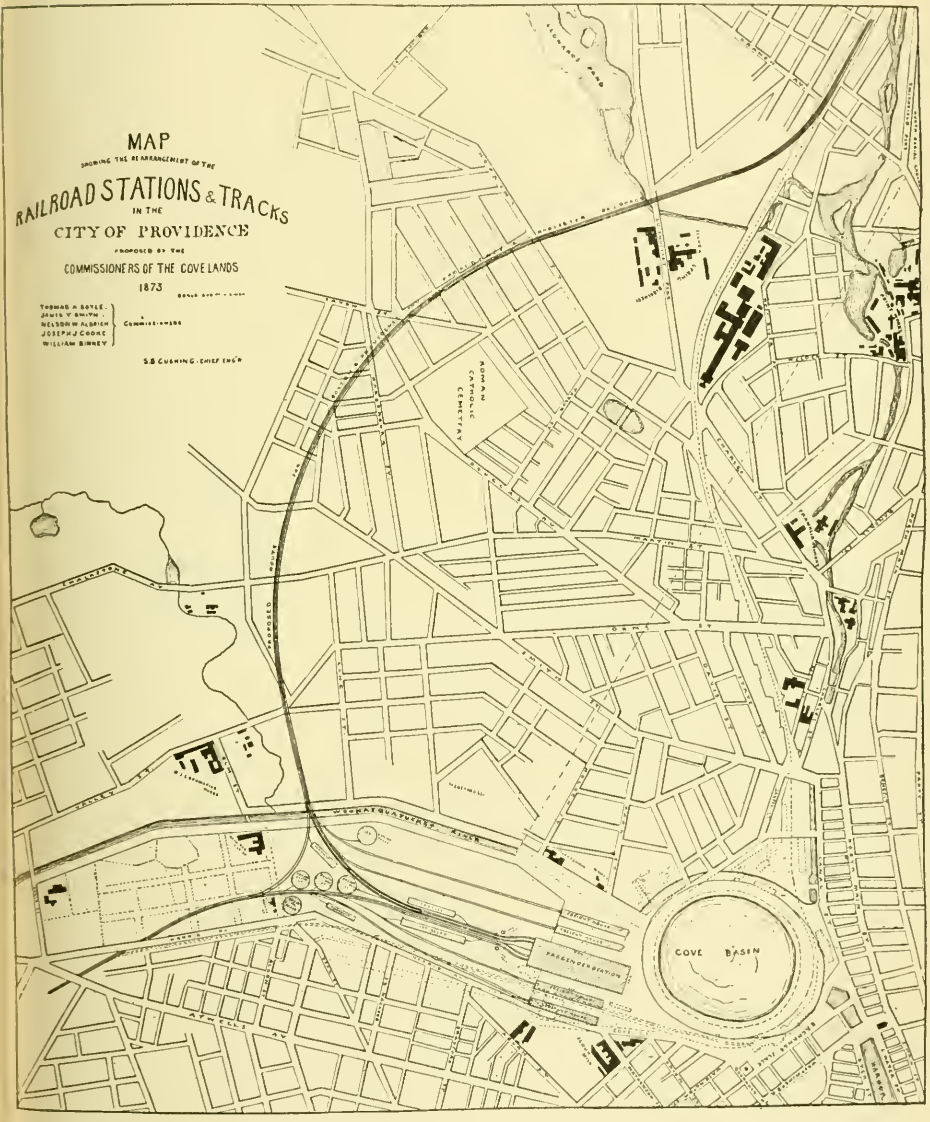
Objections to a surface layout, on the other hand, were equally pertinent and potent, the principal ones being inaccessibility of the freight yards for the Smith's Hill and Woonasquatucket Valley sections; tortuous streets necessary to a comparatively easy grade and the inability to provide more than two convenient highways across the tracks, over which the teaming for these sections, north and west, would have to be done. From this point of view it was seen that the question was not so much one of "walled barriers" as of limited highways; and in preparing plans, which were finally adopted, this fault was corrected by the writer suggesting an additional street to begin at a point nearly in front of the City Hall, pass through the center of the railroad layout and connect with Francis Street at the foot of Smith's Hill. This main thoroughfare, in addition to Gaspee Street on the westerly and Promenade Street on the easterly end of the station layout, gave a new, direct, commodious highway of easy grade from the center of the city to Smith's Hill. The station was located immediately over it, thus making the street the central feature of the plan. The impossibility of securing such adequate street facilities by a surface layout materially aided in deciding the question between these two types.

The following is a brief review of some of the principal plans considered and will show the variety of ideas presented and how the difficulties of the engineer were increased by the necessity of solving other than the purely engineering features of the problem. The plans here referred to are not all that were presented; the main features, however, are covered in those described.

Doyle Plan.

"In 1873 Mayor Thomas A. Doyle appointed a commission, which a year or two later proposed a radical change in the railroad

system of Providence by abandoning the joint location of the Boston and Worcester roads, from a point north of Corliss' Engine Works, and building a new road west of Smith's Hill,



known as the Pleasant Valley route, terminating in a stub-end station west of the Cove basin, about one quarter of a mile from the present station." By this plan all New York and Boston

trains passing through Providence were obliged to back in or out for a distance of nearly a mile. "This scheme fell through as the railroad companies saw no good reason for giving up the valuable franchise held by them and the city did not seem inclined to take their property for other public use, the only purpose for which it could legally be taken." *

Railroad Plan.

In the year 1873 the railroads brought out a plan for enlarging the old station by constructing additional tracks, platforms and shelters on Cove land in the rear, substantially what was done in later years to afford a means of temporary relief. The plan included overhead bridging at Railroad Crossing and Gaspee streets, but the incline approaches of these streets were too steep to be practicable. This makeshift, which had the one merit of cheapness, did not receive serious consideration. The panic of 1873 put a quietus on terminal facility agitation for eight years.

Harris Plan.

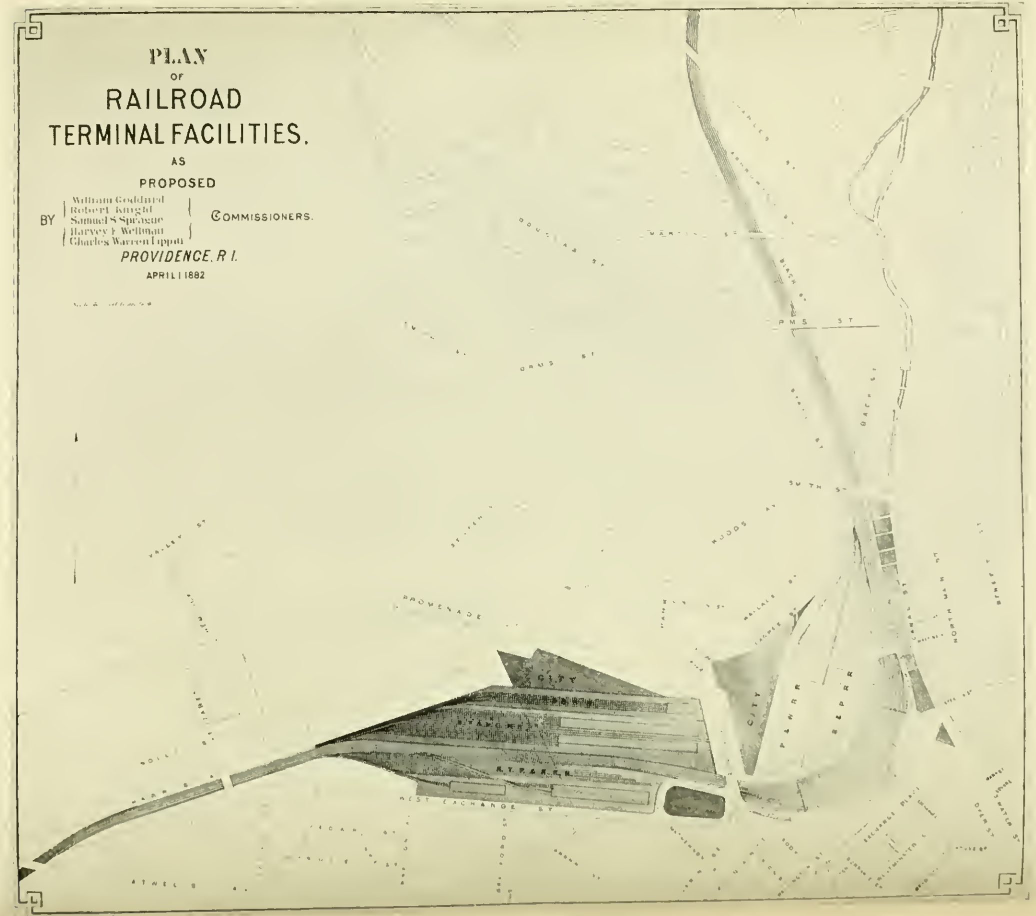
"Wm. A. Harris plan appeared on December 6, 1881. He was a believer in the head house idea and located the depot on the site of the old one. Tunnel routes were proposed through Smith's Hill and Branch Avenue via Senter Street at the Vitriol Works. It was an elevated station and Dorrance Street was extended under the tracks to the foot of Smith's Hill. Promenade Street was opened to Canal Street without a railroad crossing. The freight yards were east of the depot and were reached by present tracks through Smith's Hill cut. A singular proposition was that for arching over the tracks from Smith to Charles Street, a distance of half a mile, so as to reclaim the land above the rails. A second tunnel was from Dean to Dale Street. Every detail of the Harris plan was thoroughly worked out." †

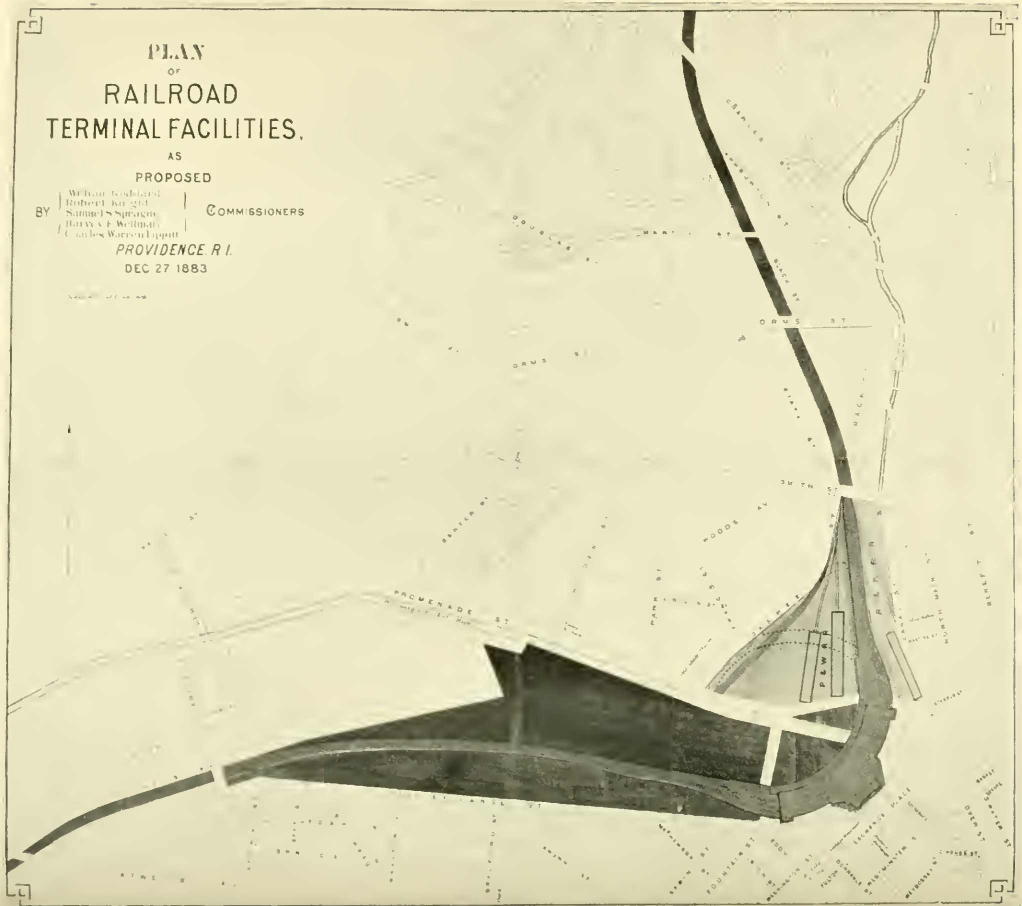
Goddard Plan (Surface).

"In August, 1881, the Boston & Providence and the Providence & Worcester Railroad companies petitioned the city government for the grant or purchase of certain filled and unfilled lands belonging to the city. This petition led to action on the part of the city council, which resulted in the appointment by

* Minot: "Railroad Terminal Facilities in Providence," Journal of the Association of Engineering Societies, November, 1890.

† Providence *Journal*, November 11, 1893.


PLAN
OF
RAILROAD
TERMINAL FACILITIES.
AS
PROPOSED
BY
William Goddard
Robert Knight
Samuel S Sprague
Harvey F Wellman
Charles Warren Lippitt
COMMISSIONERS.
PROVIDENCE, R.I.
APRIL 1 1882
CITY
WEST EXCHANGE ST
PROMENADE
P & W R R
B & P R R
CANAL ST
NORTH MAIN ST
WOODS ST
SMITH ST
CHARLES ST
PROMENADE
VALLEY ST
OGDEN ST


PLAN
OF
RAILROAD
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BY
William Goddard
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Samuel S Sprague
Harvey E Wellman
Charles Warren Lippitt
COMMISSIONERS
PROVIDENCE. R I.
DEC 27 1883
CHARLES ST
DOUGLAS AV
ORMS ST
BLACK ST
SMITH ST
WOODS AV
PROMENADE ST
CANAL ST
NORTH MAIN ST
P&W R R
EXCHANGE PLACE
DYER ST
FOUNTAIN ST
EDDY

Mayor Hayward of what was commonly known as the Goddard Commission, consisting of Wm. Goddard, S. S. Sprague, Robert Knight, H. E. Wellman and Charles Warren Lippitt, all well-known business men of the city." *

Under instructions of the city council, the commissioners were to appraise the lands belonging to the city known as the Cove and Cove lands, to fix the price thereof and to negotiate the sale or exchange of the whole or any part of said lands with the several railroad companies desiring to purchase the same; also to report to the city council, on or before April 1, 1882, a plan or plans for the increase of railroad terminal facilities for both freight and passengers and such new streets as may be necessary in consequence of the adoption of their proposed plan or plans.

"The commission made their report April 17, 1882. The plan proposed provided for filling the Cove basin; reserving walled channels for the waters of the Woonasquatucket and Moshassuck rivers, the widening of Exchange Place about 125 ft. and the location of a through passenger station on its northerly line, substantially in the rear of the present station and for overhead crossings, carrying the highways over the railroads." *

Upon presentation of this report, Mr. Samuel L. Minot was employed by the Boston & Providence Railroad and Mr. John W. Ellis by the Providence & Worcester Railroad to make an estimate of the cost of this plan and report upon its feasibility. It was decided that the cost of the scheme was too great, the feature of the overhead crossings proving very expensive, besides which, the method of approaching the freight yards and houses of the two roads was unsatisfactory. The result of this study was a suggestion to the commission that a modification of their plan, keeping in view the main purposes they wished to accomplish, but elevating the station and carrying the structure and tracks over the streets, would afford a solution of the difficulties and, if accepted, secure a plan fundamentally correct. These suggestions were cordially received by the commission and incorporated in a new plan.

Goddard Plan (*Elevated*).

"The commission presented their second report to the city council, December 27, 1883. The plan contemplated an elevated station in substantially the same location as the previous report. The approach from Smith Street was on a grade of 23 ft. per mile

* Minot: "Railroad Terminal Facilities in Providence," Journal of the Association of Engineering Societies, November, 1890.

and from the west on a grade of 18.5 ft. per mile. Highways were to be built across the Cove, which was to be filled in as in the previous scheme, affording ample and easy access to Smith's Hill, though, perhaps, by not the most direct route." * Some modifications of this plan, desired by the engineers, would probably have saved it from certain prejudices which were afterwards developed.

" Much opposition to the plan was created, led by George H. Corliss and Judge Charles S. Bradley. The main point and aim of the opposition, as presented to the committee, was that the railroad companies ought to be compelled to move from their present situation to the Cove lands west of Gaspee Street." The cry of " railroad monopoly " was raised, also " Chinese walls," and the bridges under the elevated road were designated as " rat holes," although their capacity for the admission of light was larger than that of the bridges under the elevated railroad and station at Philadelphia and were of about the same length. All this affords interesting reading to-day, in the light of such object lessons as Francis, Promenade and Gaspee streets. Much eloquence was expended upon the beauties of the Cove basin and Promenade, concerning which the Railroad Commissioner in his report for 1891 wrote, " The Cove, which had become little else than an enlarged cesspool, and of no value except as a breeding place for noxious insects and unsavory odors, has been nearly filled up." The report and plans were accepted, however, by the city council and within two months by the Boston & Providence Railroad, New York, Providence & Boston Railroad and Providence & Worcester Railroad.

The commissioners were authorized by the city council to negotiate with the railroad companies for the sale or exchange of lands, but as there was lacking legislative authority for *taking* land, application was made to the General Assembly, which passed a bill to enable the city of Providence and the railroads to carry out the plan adopted. Acting under this authority the commissioners continued their labors for carrying it into effect until November, 1886, when the Providence & Worcester Railroad finally rejected the plan. " Rather than spend any considerable sum for improvement in Providence, the managers of that road seemed to prefer a prospective 10 per cent. lease of their property based on a million increase of capital stock, soon after applied for to the Massachusetts legislature, on the pretext, in part, of the necessity for making these very improvements. In the correspondence of the president of the company with Colonel

Goddard, it was contended that it was impracticable to build the structures proposed in the Cove on account of the very difficult foundations, an opinion contrary to that of his own engineers. This correspondence is interesting reading to-day in view of actual tests that have been made." *

"As soon as the Worcester road withdrew its acceptance of the plan, the Goddard Commission resigned, after devoting a great deal of their time, for nearly five years, ably, conscientiously and gratuitously to the service of the city." *

Nicholson Plan.

On January 17, 1884, Alderman Wm. T. Nicholson submitted a resolution amending the second Goddard Plan, which consisted principally in a rearrangement of and addition to the street layout, the object being to get more direct and ample highways between the central portion of the city and Smith's Hill.

Corliss Plan.

"George H. Corliss brought forward a plan similar to that of the Commission of 1873. This seemed to be the favorite scheme of the opponents of the commissioners' plan, especially of those owning land west of Smith's Hill and in the Woonasquatucket Valley west of the Cove land; also of the esthetic gentlemen interested in preserving the Cove as a public park." *

Charles Warren Lippitt Plan.

"A head-house plan was credited in 1884 to Charles Warren Lippitt." This plan provided for a new depot situated westerly of the old station and fronting on Exchange Place, which was reached by tracks carried in tunnel under Smith's Hill from Branch Avenue. "Freight yards were on either side of the river. There was a "Y" at the Cove end of the tunnel. The outgoing tracks to New York were carried over the river between the Locomotive and File Works." The existing location in the cut through Smith's Hill as far as Corliss Engine Works was abandoned as a railroad and reserved for a boulevard.†

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* Minot "Railroad Terminal Facilities in Providence," JOURNAL OF THE ASSOCIATION OF ENGINEERING SOCIETIES, November, 1890.

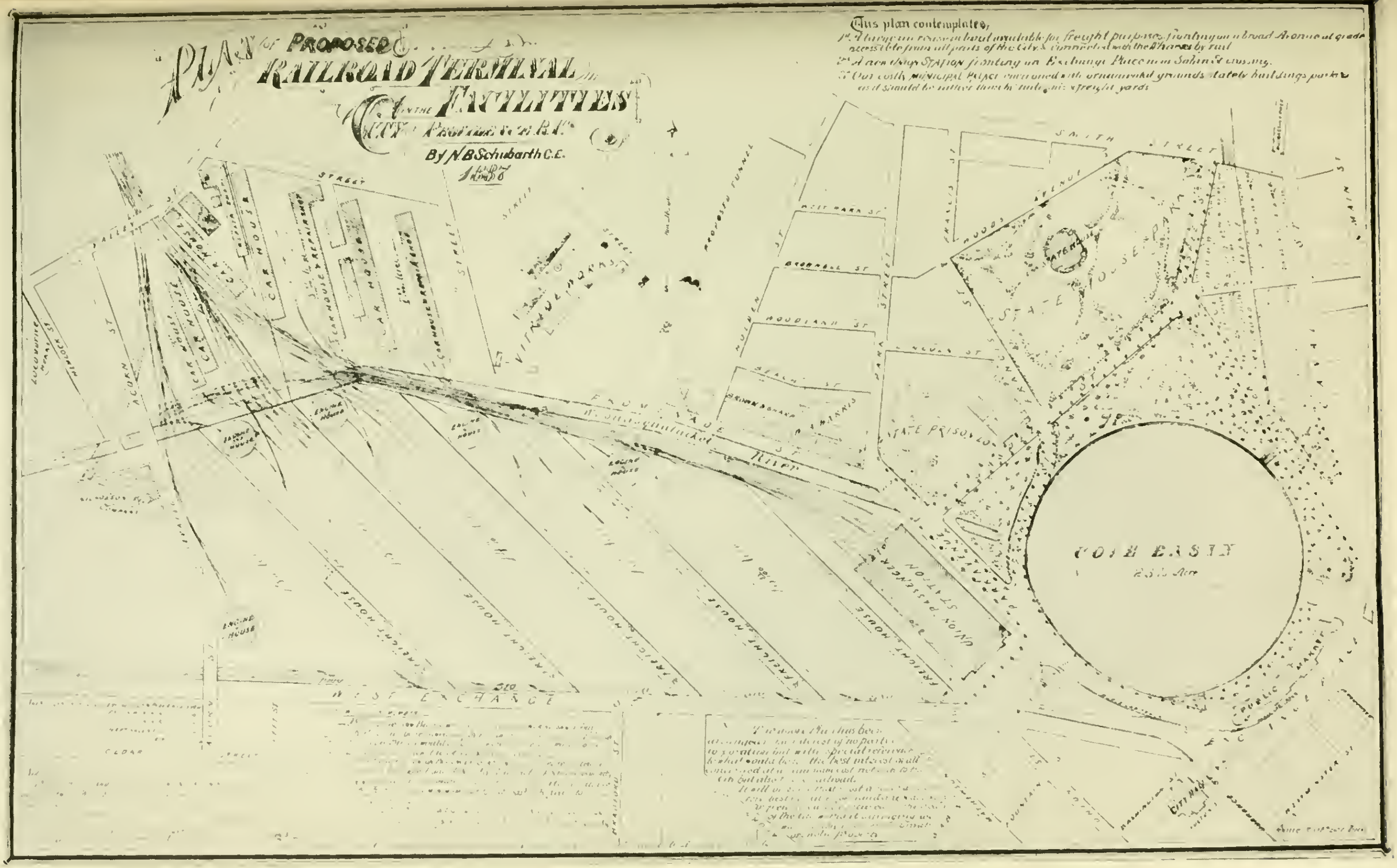
† Providence *Journal*, November 11, 1893.

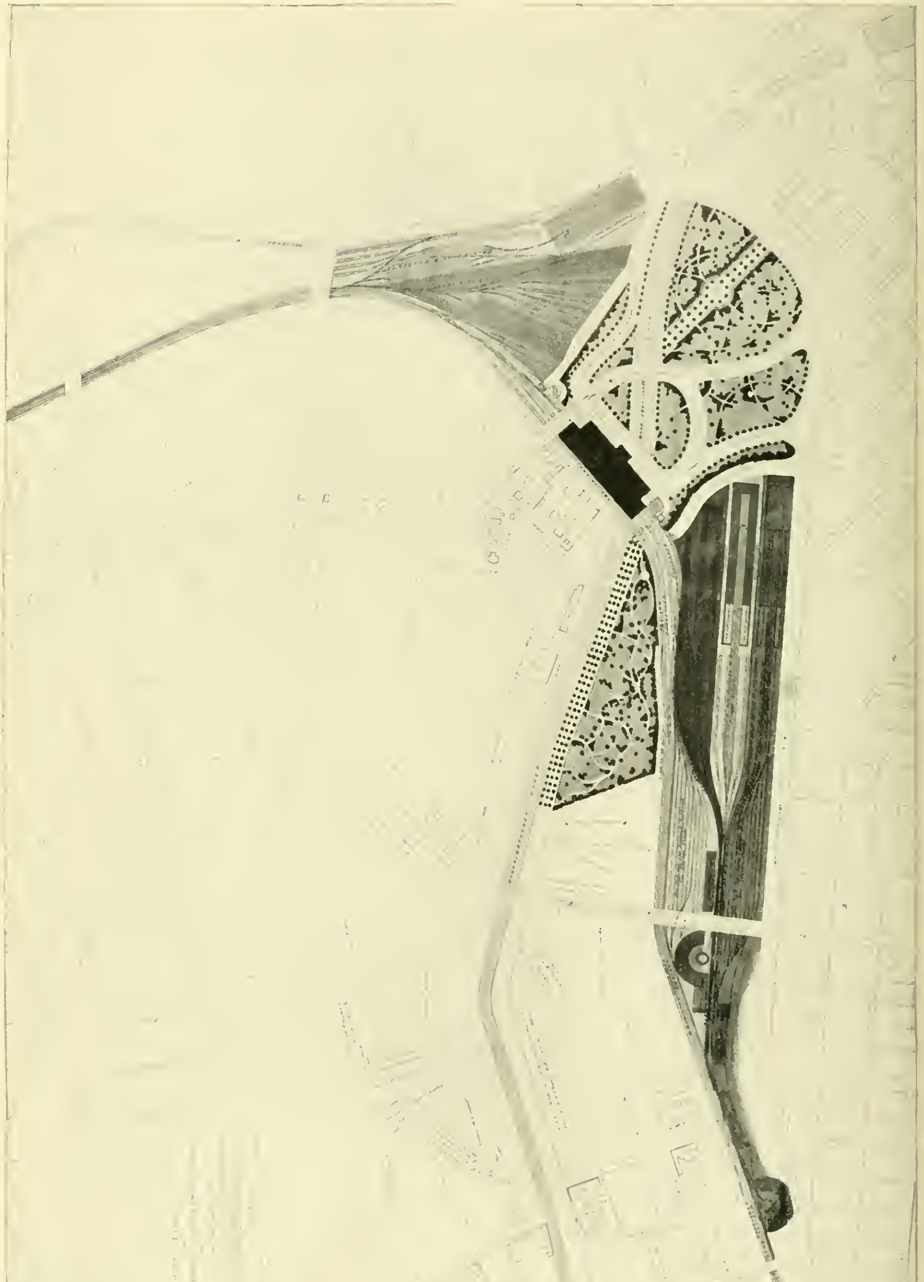
Schubarth Plan.

This plan was presented in report of the Public Park Association in 1887 and was prepared by N. B. Schubarth, civil engineer. The object of this plan was the preservation of the Cove and surrounding land as a public park and to meet the objections of the residents and property owners on Smith's Hill to the Goddard Plan. It contemplated the abandonment of the existing Smith's Hill entrance and the transfer of all railroad accommodations, both passenger and freight, to a point west of the Cove basin. The Cove was to be partially filled, and, together with land to be abandoned by the railroads on Canal Street and at the site of the then existing station, was to be converted into a public park, the old depot being kept and used as a public market. The proposed new Union Station was located west of the Cove basin on West Exchange Street about opposite Union Street. Extensive freight layouts were planned fronting on West Exchange Street and extending back to the Woonasquatucket River, which arrangement necessitated very expensive river bridging for nearly half a mile of its length. Entrance into the city from the north was via the so-called Pleasant Valley route, similar to that contemplated by the Doyle Plan; or, as an alternative, by tunnel under Smith's Hill.

Experts' Plan.

Terminal facilities continued to be a subject of agitation before committees of the city council and of the State General Assembly during the winter, spring and summer of 1887, but with no result until September of that year, when the city council passed the following resolution: "Resolved, That his honor the mayor be and is hereby requested to appoint a commission, to consist of three impartial and disinterested persons residing without the state, who shall be practical and skilled railroad engineers, and who shall, as soon as possible, visit the city of Providence and after making a thorough examination of the present terminal facilities of the railroads entering the Cove lands within the said city, the topography of the lands contiguous and adjacent thereto, together with the requirements for an adequate accommodation of the public, report to the city council, for their approval, the best plan in their judgment for enlarged terminal facilities for said railroads, including therein locations and general plans for a new passenger station, freight houses, together with approaches and track connections therewith. . . ." Pursuant to the authority given by this resolution Mayor Gilbert F. Rob-


PLAN of PROPOSED RAILROAD TERMINAL FACILITIES
in the CITY of PROVIDENCE R.I.
By N. B. Schubarth C.E.
1887
This plan contemplates,
COVE BASIN
STATE HOUSE PARK
UNION PASSENGER STATION
FREIGHT HOUSE
CAR HOUSE
ENGINE HOUSE
STATE PRISON LOT
SMITH STREET
PROPOSED TUNNEL
WEST EXCHANGE
PUBLIC MARKET
CITY HALL
HOLDEN ST
WEST PARK ST
BROMHALL ST
WOODLAND ST
BEACH ST
CANAL ST
MAIN ST
ACORN ST
HEMLOCK ST
VALLEY ST
CEDAR
FRANCIS ST
WOONASQUATUCKET RIVER
PROMENADE ST



bins appointed as a Commission of Expert Engineers, Joseph M. Wilson, of Philadelphia; D. J. Whittemore, of Milwaukee, and Alfred P. Boller, of New York.

"The plan the commission reported to the city council April 13, 1888, provided for a new location around the foot of Smith's Hill, a passenger station to be located near the old State's Prison, the filling in of the Cove basin, preferably for a public park, and the elimination of grade crossings, the streets being carried overhead. The passenger station was to comprise a train shed 560 ft. in length with five tracks under cover, flanked on the south by the station building proper and facing the proposed park. Two of the tracks were for through passenger business and three for local trains. There were to be two tracks outside the train shed for through freight. The freight yards and houses of the roads entering from the north and east were to be between Canal Street and the through tracks, and of those entering from the west between West Exchange Street and the through tracks. The chief argument for the plan was the saving in distance of 1 730 ft. and in curvature of 79½ degrees, and the consequent saving in cost of operation for through trains of about $10 000 per annum." *

The plan was accepted by the city council with alacrity, but was not acceptable to any of the railroad companies. "The location of the freight yards, while quite convenient for those doing business south and east of the railroads, was very inconvenient for the manufacturing establishments in the Woonasquatucket Valley west of the old State's Prison." * The scheme of overhead crossings was an objectionable feature of the plan and one tending to restrict its future development. The passenger station was badly located for fostering the growing suburban business of the different roads and was limited in accommodations provided for train service, which about equaled the requirements of that period, but were wholly inadequate to the future growth and needs of the city. Besides, it was impossible to enlarge the station in length or width, leaving the streets as adopted by the city council.

Various modifications of this plan were suggested by different local engineers. One of these appeared in the Providence *Journal* May 18, 1888, and showed one method of treating the overhead crossings to afford better access to Promenade Street and the manufacturing concerns located west of the station in the

* Minot: "Railroad Terminal Facilities in Providence," JOURNAL OF THE ASSOCIATION OF ENGINEERING SOCIETIES, November, 1890.

Woonasquatucket Valley. A new street, practically an extension of Eddy Street, was carried over the tracks to the west of the station and connected with Promenade Street at a point about opposite Park Street.

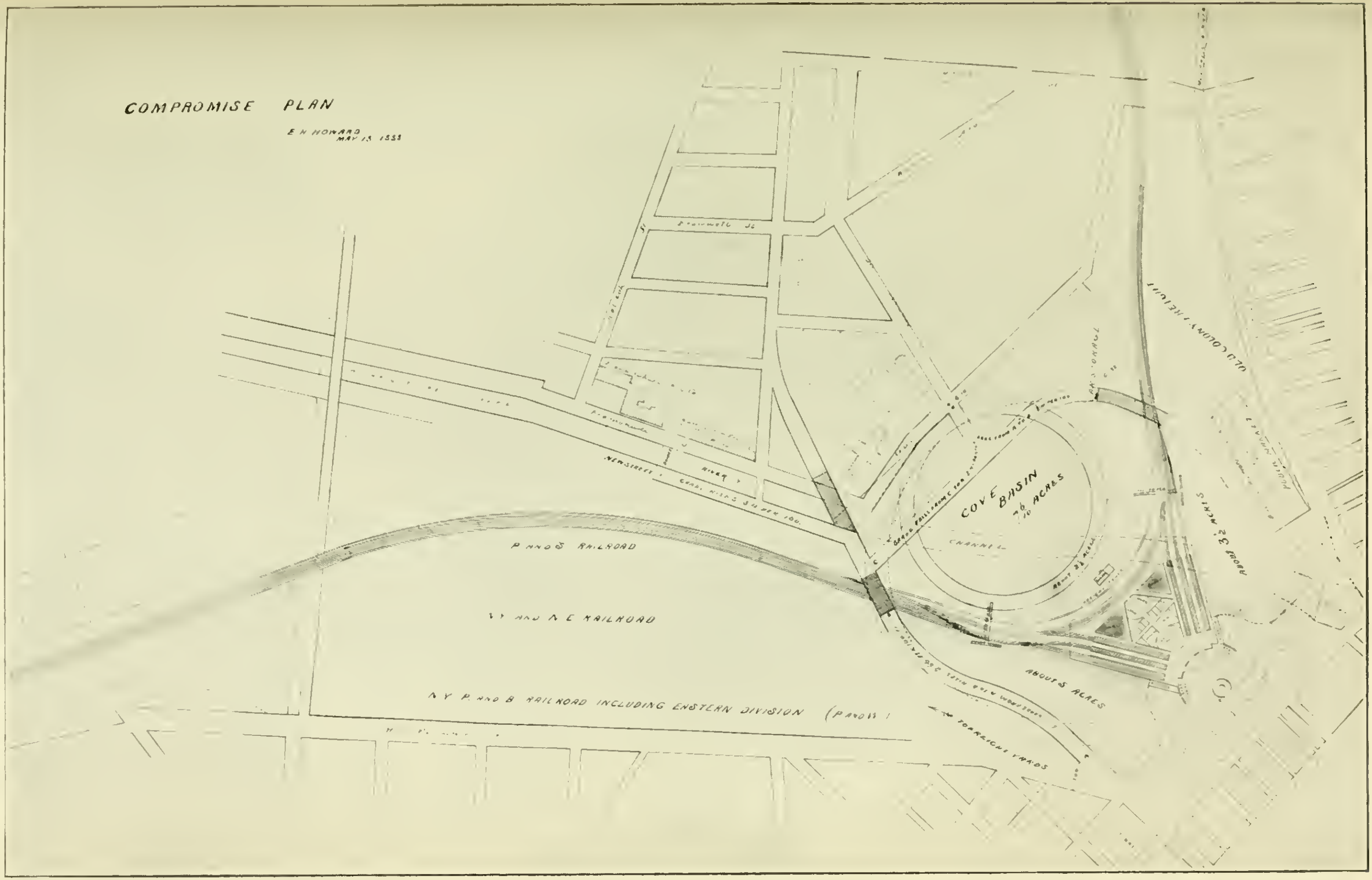
Still another modification of the Experts' Plan was presented to the city council December 17, 1888. Holden Street was to be extended across Promenade Street and over the river to connection with a proposed new street 80 ft. wide, running parallel with the Woonasquatucket River, and, rising on a 3 per cent. grade, was to cross over the tracks at the westerly end of the station and thence to West Exchange Street about opposite Sabin Street. The Commissioners' Plan provided for only a footbridge at this point, and no connection was afforded with the large territory west of the tracks. Francis Street was to be preserved at the easterly end of the station, but a new street was to intersect it near the station which would have an outlet on Canal Street nearly opposite Steeple Street.

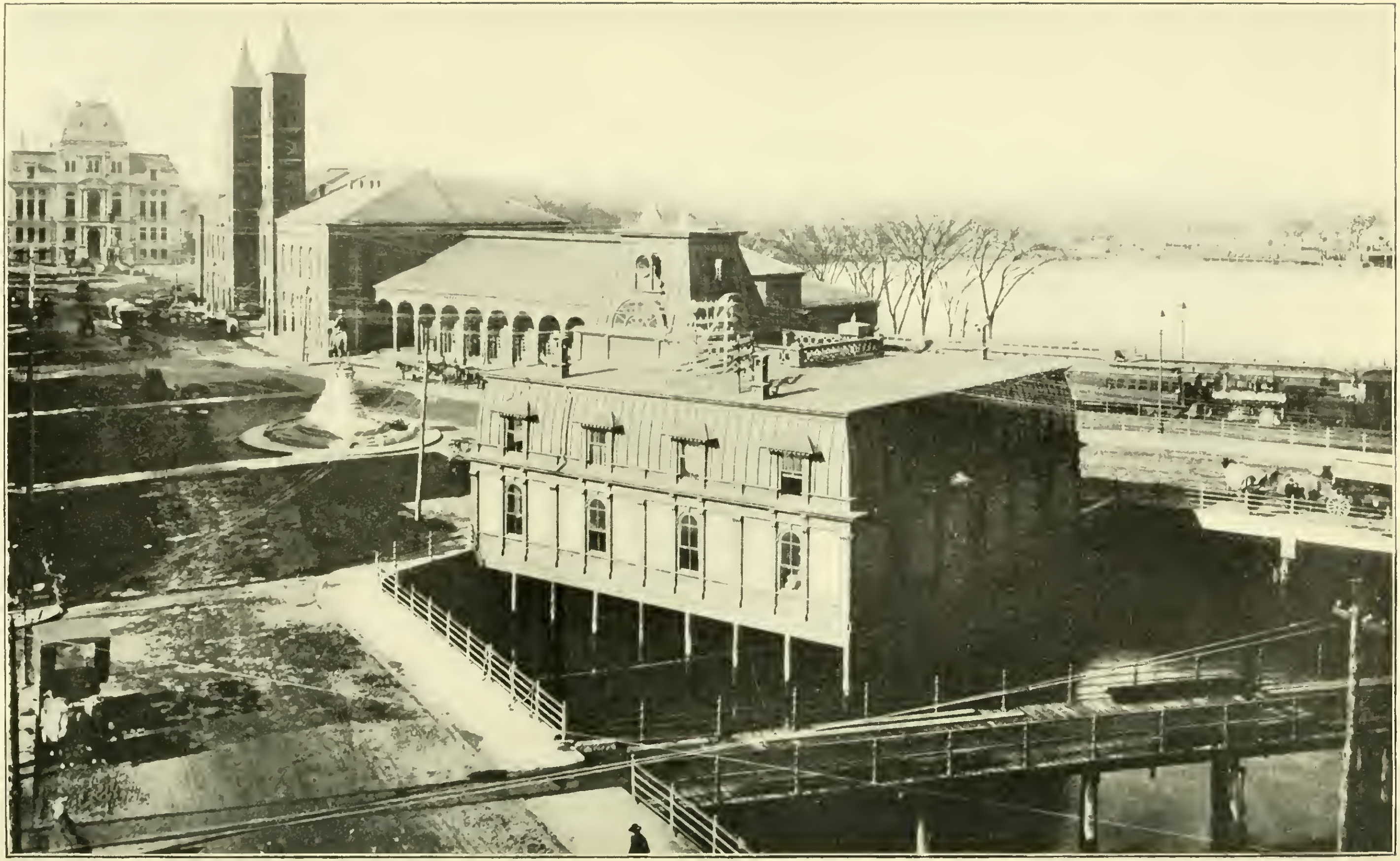
Neither the original Experts' Plan nor subsequent modifications of the same which had been suggested was adopted by the municipal authorities, but it was decided to build masonry channels for the two rivers, connecting at a point in the Cove basin, and then to fill in behind the walls of these channels with gravel. The contract for the wall work was let in September, 1888, to James J. Newman, of Providence, R. I., at $193 921. Other expenses connected with this work increased the cost to the city by about $100 000. This work was under the charge of the city engineer, with Wm. D. Bullock as assistant engineer and Henry N. Francis as resident engineer. The work of filling the Cove basin was let to the Providence & Springfield Railroad Company.

The railroad companies, fearing that the Experts' Plan was to be forced on them, wrote the committee in charge of terminal facilities objecting to the proposed location of channel walls for the rivers, particularly those for the Moshassuck River, which was sure to come under the easterly approach of any layout that would meet with their approval.

Compromise Plan.

This plan was designed by Elisha H. Howard, and, as its name indicates, was a compromise, embodying, as far as possible, the desires of all parties, by preserving the distinctive features of the various schemes, having for its object the harmonizing of the various conflicting interests so that some tangible results,


COMPROMISE PLAN
E H HOWARD
COVE BASIN
CHANNEL
N Y AND N E RAILROAD
N Y P AND B RAILROAD INCLUDING EASTERN DIVISION
ABOUT 5 ACRES
ABOUT 3½ ACRES
OLD COLONY FREIGHT
TO FREIGHT YARDS



View of Original Union Passenger Station.

in the way of actual construction, might be achieved, "a consummation devoutly to be wished."

To every plan that had been presented there were objectors. Some wanted a station located in the rear of the Cove basin; others desired to preserve the existing site. Some wanted a through station; others preferred a stub-end station. Some wanted the Cove filled; others wanted it left open. This plan preserved some of all of these features, in the following manner:

The present effect of the old Cove was to be preserved by the construction of a smaller circular basin having an area of a little more than 7½ acres. The remaining portion was to be filled. Subsequently, however, this feature of the plan was abandoned in favor of filling the Cove in its entirety.

The site chosen for the station was about midway between the one then existing and that chosen by the Experts' Plan. The space fronting on Exchange Place, about nine acres, was laid out as a park. Two streets were provided for the people of Smith's Hill and the Woonasquatucket Valley, one at the easterly end of the station and the other at the westerly end, and were carried over the tracks.

The buildings were arranged in the form of a large triangle with the converging ends terminating in a crescent-shaped building fronting on Exchange Place. It combined the features of both a through and a stub-end station.

For the local trains entering from the east and west, separate head-houses were designed, each containing six stub-end tracks. These buildings formed the sides of the triangle, the ends opening on to a large concourse. The building forming the base of the triangle was for the through trains and contained two tracks. An additional track was provided outside this structure for through freight. The waiting-rooms, general offices, restaurant, trainmen's quarters, etc., were provided in the central space formed by these structures.

An endeavor was made to perpetuate the style of architecture of the old station, for which there was a strong feeling of sentiment among many citizens. The author is indebted to Elisha H. Howard for the information regarding this plan.

Railroad's Plan.

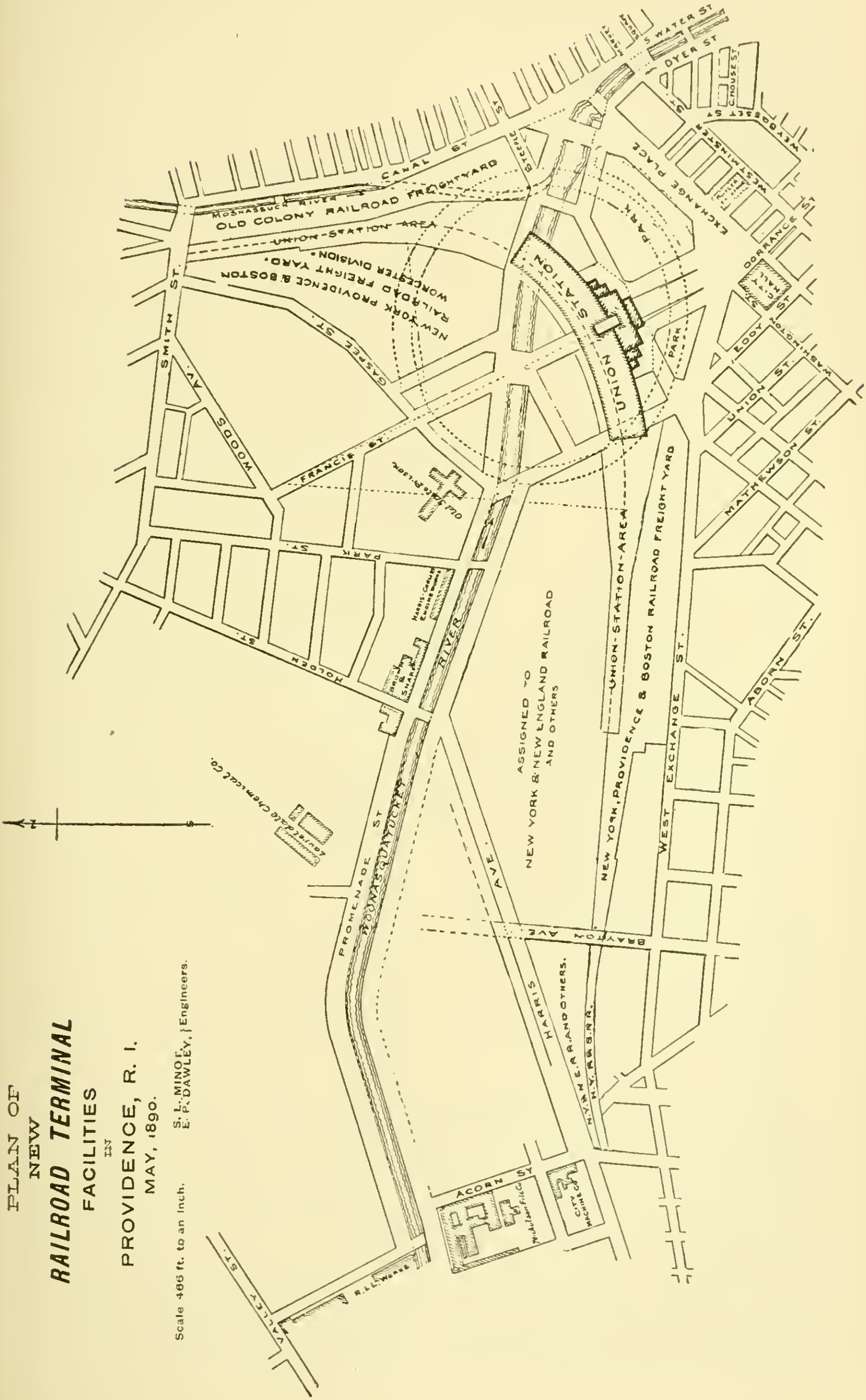
In the summer of 1888, the New York, Providence & Boston road had come into possession of the Providence & Worcester road by lease, and the Old Colony road, of the Boston & Providence road. The managers of the two roads, J. W. Miller and

J. R. Kendrick, respectively, informed the committee on terminal facilities of the city council, of which Wm. P. Vaughn was chairman, that they wished to have plans prepared with a view of reconciling the conflicting interests of the city and railroads. S. L. Minot, Engineer for the Old Colony Railroad, and E. P. Dawley, Chief Engineer for the New York, Providence & Boston Railroad, were directed to examine and report upon two studies for proposed terminal facilities. One was for an elevated road and station; the other, a surface road, with highways carried over the tracks. In either plan the location of the station was to be in the rear of and adjacent to the present depot.

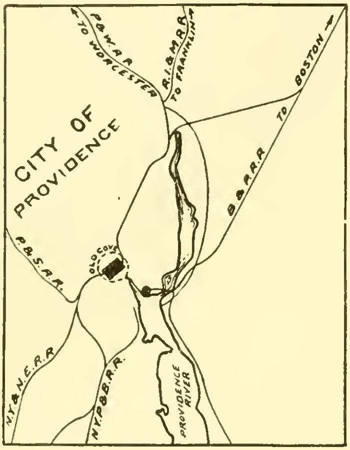
The final report of these engineers was made January 16, 1889, and referred to Plan " A " (a surface layout, with highways passing over the tracks) and Plan " B " (an elevated scheme, with streets carried under tracks). Plan " A " was abandoned, not without reluctance, due to the fact that a certain portion of the public had maintained that the new layout should be a " surface " one, i. e., with streets carried over the tracks. Plan " B " was for an elevated layout, so called. It provided for the location of a station and approach tracks on a raised embankment, with streets and highways carried underneath. The advantages of this layout were obvious. All trains would be out of the way of the public; they could be run with absolute safety to and from the station; railroad property could be fully enclosed and protected; the platforms of the station could be kept private from all passengers until the arrival or departure of trains.

On account of the above reasons Plan " B " was taken for further study and elaboration, the result, after months of careful and painstaking study, being embodied in what was known as Plan " X," or the Railroad's Plan.

To draw a plan which would overcome all objections that the discussion of some twenty years' consideration had adduced was no small task. When presented, it so successfully defied adverse criticism that it had no outspoken opponents. It was designed to embrace all the good features of the plans that had gone before and omit all the bad ones, harmonizing the interests of both city and railroads and meeting the objections of all reasonable opponents of previous schemes. It can be said that it was a plan designed in all its features by railroad men and railroad engineers, who were reasonably conversant with the needs of the railroads and the notions of prominent citizens, and with some slight modifications it was accepted by all parties interested and finally carried out.


PLAN OF
NEW
RAILROAD TERMINAL
FACILITIES
IN
PROVIDENCE, R. I.
MAY, 1890.
S. L. MINOT,
E. P. DAWLEY, } Engineers.
Scale 486 ft. to an Inch.
UNION STATION
UNION-STATION-AREA
OLD COLONY RAILROAD FREIGHT YARD
MOSHASSUCK RIVER
NEW YORK PROVIDENCE & BOSTON RAILROAD FREIGHT YARD, WORCESTER DIVISION.
NEW YORK, PROVIDENCE & BOSTON RAILROAD FREIGHT YARD
ASSIGNED TO NEW YORK & NEW ENGLAND RAILROAD AND OTHERS
WOONASQUATUCKET RIVER
CANAL ST
SMITH ST.
WOODS AV.
GASPEE ST.
FRANCIS ST.
PARK ST.
HOLDEN ST.
PROMENADE ST
AVE.
HARRIS
BRAYTON AVE
WEST EXCHANGE ST.
MATHEWSON ST.
UNION ST.
EDDY ST.
ABORN ST.
DORRANCE ST.
WASHINGTON
WESTMINSTER
WEYBOSSET ST
EXCHANGE PLACE
PARK
DYER ST
S. WATER ST
C. HOUSE ST
CITY HALL
STEEPLE
ACORN ST
VALLEY ST.
N.Y. & N.E. R.R. AND OTHERS.
N.Y. P. & B. R.R.
CITY MACHINE CO.
R. L. L. WORKS
Rumford Chemical Co.
Harris-Corliss Engine Works
Brown & Sharp

The following are some of the salient features of the plan; which may perhaps be best described by reviewing the consideration given their embodiment in the general layout. Each of the main features was the result of much study, and final combination and conclusion were only arrived at after great labor in preparing drawings, estimates of cost, comparing plans, making tentative layouts of buildings, approaches, etc.



STATIONS IN PROVIDENCE
1900

The first point considered was, Shall the station remain near its present site or be removed to the rear of the Cove, as had been proposed by eminent engineers? As public opinion had been fully expressed on this point and was in accordance with the views of the management of the railroads, it was finally settled in favor of keeping it as near to the present station as it was possible to do and accomplish all else that was desirable.

The next question was, Shall the streets go over the tracks or the tracks over the streets? This question settled itself in favor of placing the tracks over the streets for the following reasons:

First. The present station being in the valley, with down grades approaching it of from 15 to 40 ft. per mile, and lying only a few feet above tide water, it was impossible to much further depress the tracks.

Second. By keeping the new station near the present one the streets could not be carried over without long and winding inclines.

Third. It seemed very undesirable to forever shut out the large Woonasquatucket Valley from all communication with the center of the city except by these overhead bridges, and also very unfair to the railroads, which would of necessity have their freight yards located so that the bulk of their team freight should be hauled over the bridges.

Fourth. The natural solution was to reverse the track grades and let the tracks approach the station on ascending grades, a condition most desirable in the operation of a large station.

The prime feature contended for by the city (next to the removal of grade crossings) in any plan had been direct and ample street communication between the central portion of the city and Smith's Hill. To meet this demand a street 80 ft. wide (afterwards widened to 100 ft.) was drawn, extending from the center of the city or the square in front of the City Hall to the best street ascending the hill. The grade of this street was fixed on the present surface and the surface of the filling to be made in the Cove, it being from 5 to 10 ft. above mean high tide. This being the most direct route possible between the center of the city and the hill, it could not be criticised. To make it still more desirable it was determined that no freight yards should front thereon.

Then came the question of how to get the tracks over this new street and not make a dark and undesirable crossing. Only the through tracks, four for passenger and two for freight, were allowed to go over, and as there were to be various other stub-tracks for local trains, it was necessary to stop them on each side of this street. A bridge was, therefore, conceived which would carry the through tracks as shown on the plan, and after various studies of how to arrange the depot building so that there should be but one general waiting room and set of ticket offices (a feature insisted upon), it was decided to bridge this street at one more place, separate and apart from the track crossing, and place the waiting room, in part right over the street, thus securing for it plenty of light and ventilation from above and easy access from either side of this particular street below. This gave two bridges over this main street, each of reasonable width, with 14 ft. clear height and a stretch of open daylight 118 ft. long between. Two other streets were projected, each 70 ft. wide, under the tracks at the ends of the station, each to serve a purpose and to take the freight business away from the main thoroughfare. No other plan had so well provided for street accommodation across the tracks.

Next came the question of how to arrange the front of the station so that there would be no Chinese walls and so that it could not be called an elevated station. This was done by placing it back just far enough to permit of sloping the approaches to a reasonable carriage grade on each side of the main street to the hill. There were provided up this slope four carriage approaches, two with grades of 4 ft. per hundred, one of 3 ft. per hundred and one of 2 ft. per hundred. There were no steps up into the depot from the point where a carriage would leave its occupants.

The track approaches to the station were on embankments and no walls were designed to sustain them.

The saving in distance for through trains over the former alignment was 840 ft., as against 1 730 ft. saving by the Experts' Plan. The saving in curvature was $79\frac{1}{2}$ degrees, the same as by the Experts' Plan. The maximum degree of curve was $6\frac{2}{3}$ degrees, while that of the Experts' Plan was 10 degrees.

The two through freight tracks passed the station in the rear of the train shed and the foundations and bridging provided for two additional tracks.

The seven acres of ground in front of the station were laid out as a public park.

On March 28, 1890, the Rhode Island Legislature passed an act enabling the Old Colony Railroad Company and the New York, Providence & Boston Railroad Company "to construct a suitable passenger station and the approaches thereto" in accordance with this plan. This act further recited that convenient and suitable accommodations should be provided in said station "and upon and over said approaches thereto for all other railroads now or hereafter entering or terminating in the city of Providence." *

On May 28, 1891, the General Assembly passed an act incorporating the New York, Providence & Boston and the Old Colony Railroad Terminal Company and in March of the following year the writer, under whose supervision the work of planning and estimating had been largely done, was appointed resident engineer. E. P. Dawley continued to represent the interests of the New York, Providence & Boston Railroad (soon after leased to the New York, New Haven & Hartford Railroad) and J. W. Ellis those of the Old Colony Railroad.

In the spring of 1893 the Old Colony Railroad was leased by the New York, New Haven & Hartford Railroad, which subsequently secured control of the New England Railroad. This consolidation of all the various roads did much to facilitate proggress in the handling of details contingent upon the expeditious prosecution of terminal facilities.

Very little could be done in the way of actual construction work on the approaches and the station layout until the river walls were built and the Cove filled in, except the foundations and abutments for the bridging of the Woonasquatucket and Moshassuck rivers. Work on the former was done by the city,

* Minot: "Railroad Terminal Facilities in Providence," Journal of the Association of Engineering Societies, November, 1890.

the railroad companies paying for that portion underlying the site of the proposed railroad location; while the latter, under the railroad freight yard, was contracted for by the railroads with Joseph Ross, of Boston.

In the interim the New Haven management, after familiarizing themselves with the general scheme, petitioned the city for certain minor modifications, and on March 20, 1894, the city council accepted the station plan as changed. No plans for a train shed were presented by the railroad at the time these modifications were requested and this question was left in abeyance until the completion of the station, with the following provision by the city: "That there shall also be constructed and completed coincidently with said structure a suitable train house of a width sufficient to cover all passenger tracks and platforms, of such character and according to such plans as shall be approved by the city council of the city of Providence."

The principal changes effected by this agreement were: the elimination of curved tracks through the station, although this increased the radius of curves at the ends from one uniform curve of 6 degrees to two curves of 9 degrees; the abutments for Gaspee and Promenade street bridges were extended to make provision for future installation of two additional freight tracks and some slight rearrangement of other tracks; radical changes in the architectural features of the station buildings, which, as originally designed, were for a different type of structure from the one built.

Construction.

Plans now being agreed upon, the work was put under construction.

Piling. — About 17 000 piles were driven on the work done by both the city and railroads, nearly 90 per cent. of the number being in the railroad structures. The piles were all spruce, varying in length from 30 to 45 ft., the specifications requiring that they should be driven for the full length or until the penetration did not exceed 1 in. per blow for the last twelve blows of a 2 000-lb. hammer falling 20 ft. with hammer line attached, or its equivalent. The piles were all in friction ground, that is, they did not bear on hard stratum and were figured for an average loading of about 8 tons per pile. The cost per pile in place ranged from $3.98 to $6.00, the latter price being for those under channel walls in the rivers.

Stone. — New England granite was used in nearly all foundations, retaining walls, bridge abutments, piers and the channel

walls for the rivers and was brought from the following quarries: Fitchburg, Quincy, Uxbridge, Northbridge, Mass.; Green Island, Me., and Smithfield and Westerly, R. I. Some stone for foundation and backing purposes was brought from quarries in East Providence.

Masonry. — Three classes of masonry were used generally.

First class consisted of stone cut to dimensions for face work in abutments and walls, this face work being estimated at an average of 2 ft. 10 in. in thickness in most of the work.

Second class consisted of uncoursed quarry-face work, in abutments and foundations.

Third class consisted of rubble work in foundations and backing for abutments and walls.

The following is a copy of the specification covering masonry work, which form was generally followed.

Masonry.

Face stone in all classes of masonry will be good, sound and clear granite from a satisfactory quarry, with no cracks, bad seams or discoloration. All stone will be laid with the stratification horizontal. Footing stone and backing will be sound stone from a source satisfactory to the engineer and laid on their natural beds. All to be done in a workmanlike manner.

BRIDGE SEAT COURSES AND PARAPET COPING.

Bridge seat courses will be quarry face, point dressed on beds, pene hammered on top, with no slack spots in same. Bearing stone will be bush hammered on top if required. Joints will be $\frac{3}{8}$ in. back to line of parapet and must be grouted.

Parapet coping will be point dressed on top and face, leaving no slack spots. They will be pitched to a width on top. Joints will not exceed $\frac{1}{2}$ in. and be grouted. All parapet coping will have good and full beds.

FACE MASONRY.

Class 1 will consist of stone cut to dimensions, laid in horizontal courses, alternating headers and stretchers, laid in cement mortar. All stone will be quarry face. All beds will be roughly dressed for their entire surface. Horizontal joints will not exceed $\frac{1}{2}$ in. for 16 in. back from the face. Vertical joints will not exceed $\frac{1}{2}$ in. for 8 in. back from the face. Headers will be 5 ft. long, when the wall will admit of that length, shall not have more rise than bed, and shall be placed only over a stretcher. Stretchers will not be less than 20 in. in width or more than 8 ft. long, and have at least one fourth more bed than rise. Courses shall not be less than 16 in. or more than 30 in. in height. Joints shall be broken at least 12 in. No course shall have more

height than any course underneath. All corners will be run with $1\frac{1}{2}$-in. chisel draft. No hammering will be allowed on the wall. Face masonry, Class 1, in abutments will be computed for payment as an average thickness of.............. In pier work it will be computed as may be specified.

Class 2 will be uncoursed quarry-faced work, laid in cement mortar. Stone to be from 16 to 30 in. in height. Joints to be vertical and horizontal. All beds will be roughly dressed for their entire surface. Horizontal joints will not exceed $\frac{3}{4}$ in. for 10 in. back from face and vertical joints will not exceed $\frac{3}{4}$ in. for 5 in. back from face. Headers will be 5 ft. long when the wall will admit of that length, shall not have more rise than bed and be placed over stretchers. There shall be at least two headers 5 ft. long in each 3 sq. yd. of face. Stretchers will not be less than 16 in. in width or more than 8 ft. long, or more height than width. Levelers shall not be less than 6 in. in height or extend less than 12 in. in from the face of the wall. There shall be no pinners. Joints shall be broken at least 9 in. No hammering will be allowed on the wall after the stone is set. Face masonry, Class 2, in abutments will be computed for payment as an average thickness of................ Pier work will be computed as may be specified.

Class 3 will consist of substantial rubble work, of stone of large size and good shape, laid in cement mortar. Every face stone shall have a good bed and its face must be at right angles to the bed. One stone out of four must extend at least 5 ft. into the wall. The face edges of the stone must be trimmed with a face hammer. Ninety per cent. of the face of the wall must be of stone exceeding 6 cu. ft. Face joints must not show more than $1\frac{1}{2}$ in. nor exceed 2 in. for a distance of 6 in. back from the face. Face masonry, Class 3, in abutments will be computed for payment as an average thickness of.................. Pier work will be computed as may be specified.

FOUNDATION AND BACKING FOR ALL CLASSES OF MASONRY.

Footing stone shall be large stone laid as headers, no stone less than 14 in. thick to be used. Eighty per cent. of them shall have at least 12 sq. ft. area. All voids and spaces shall be thoroughly filled with cement mortar and spawls.

Backing shall have good beds, joints and bonds and be of stone of large size. All joints shall be completely filled with mortar, and, if required, the whole shall be thoroughly grouted. In coursed work the backing will be leveled up with each course.

LAYING MASONRY IN FREEZING WEATHER.

Masonry may be laid in freezing weather when the mortar is treated as follows: The sand and water used will be heated hot, and, if required, sufficient salt will be used to make a strong brine in place of fresh water.

Cost. — The following table gives unit costs of masonry per cubic yard for the various classes of work, as well as the average cost per cubic yard for the various structures.

	Per Cubic Yard.
Face masonry	$11.00 to $13.00
Rubble work	4.00 to 4.75
Cut stone for bridge seats and coping	15.00 to 16.00
Cut stone for pier caps	16.00 to 19.00

Location of Structures.	Average Cost per Cu. Yd.	
	Abutments not Incl. Steps and Coping.	All Masonry.
Gaspee Street Bridge	$5.63	$6.36
Promenade Street Bridge	5.95	6.87
Woonasquatucket River	9.50	.....
Moshassuck River	7.70	.....
Francis Street Bridge (east abutment)	6.29	6.67
Francis Street (west abutment)	6.25	6.64

Bridging.

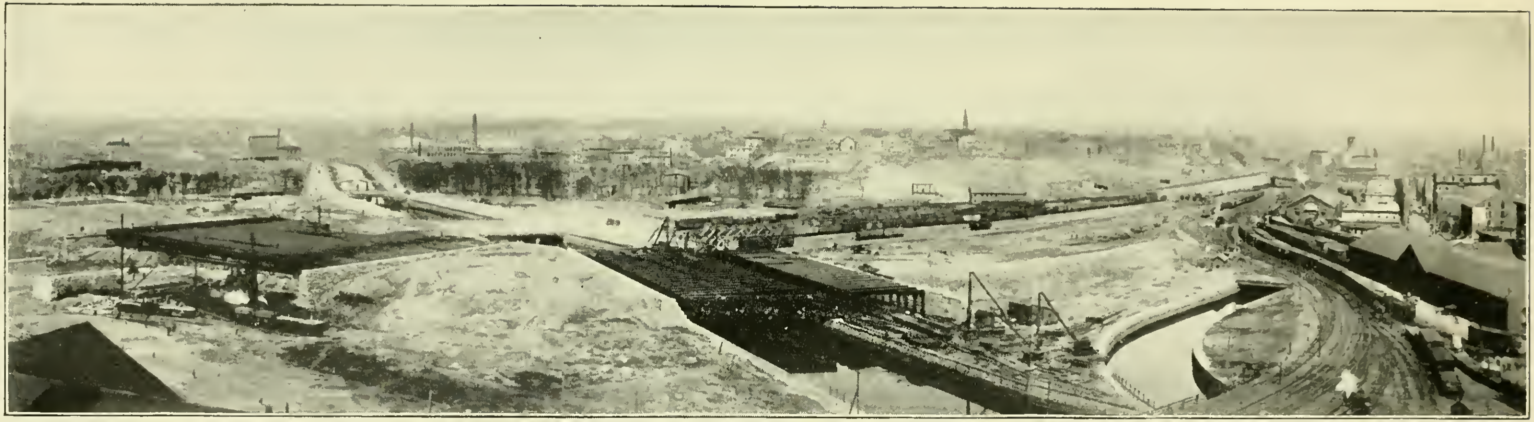
There was constructed about 4½ acres of steel bridging carrying the railroad tracks and city streets, the weight of which exceeded 7 000 tons, as follows:

Gaspee Street (railroad)	1 794 673 lb.
Promenade Street (railroad)	1 898 269 lb.
Woonasquatucket River (railroad)	3 032 672 lb.
Moshassuck River (railroad)	1 141 332 lb.
Francis Street, under station (railroad)	5 065 654 lb.
Francis Street over Woonasquatucket River (city)	1 027 414 lb.
Smith Street (railroad))	509 216 lb.

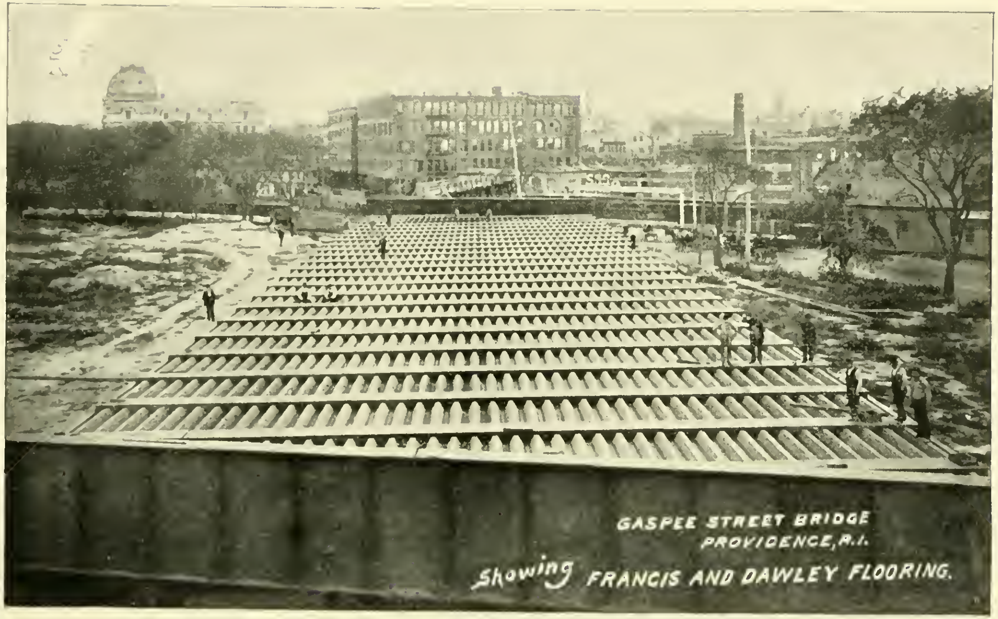
The rate paid for the steel for the greater portion of this bridging was extremely low, the average price being a little more than 2 cents per pound erected in place.

Gaspee Street Bridge. — This bridge is at the westerly end of the station and carries 12 tracks over a 70-ft. street, abolishing a very dangerous grade crossing near this point. The completed abutments and piers rest on a pile and timber grillage foundation. The work, which was done under contract with J. T. Tank, of Providence, was begun September 10, 1891, and completed October 20, 1892.

With the exception of the end girders the superstructure is



General View during Construction.


GASPEE STREET BRIDGE
PROVIDENCE, R.I.
Showing FRANCIS AND DAWLEY FLOORING.

of box girder construction. There are twenty-three of these girders arranged square to the street, resting on latticed posts placed along the curb line, with shorter spans over the sidewalks. This form of construction was used to permit tracks to be laid in any direction over the entire bridged area and to obtain the shortest spans allowable, thus saving in thickness of bridge floor in order to get 14 ft. clear head room underneath, it being undesirable to further depress the street, the surface of which was only 5 ft. above high water.

The style of solid metal flooring used on this bridge, as well as on Promenade Street and portions of Francis Street bridging, was designed by the author and E. P. Dawley, to meet special local conditions, which required a possible change in location of tracks after completion, and this condition, coupled with the large area of the bridge, made it impossible to so treat the structure as to shed the water falling upon it at the ends or sides, as is usually done. It was in fact necessary that the water should go through the structure and yet not drip over the entire under surface. The flooring consisted of a series of watertight troughs 10 in. in depth, resting on shelf angles on the webs of the box girders. The shapes were placed so that the water collected in the troughs would discharge at the ends and flow into gutters and down spouts. These gutters were made of 16 oz. soft copper attached to the lower edge of each shelf angle and supported with an adjustable bend hanger inserted over the nut of the holding-down bolt in the bridge floor. Opposite and under each of these bolts a copper cup was fastened to the gutter. The down spouts were carried inside the bridge columns and these spouts and bends at the bottom were made of 3-in. light weight soil pipe. This gutter work was done by Phillips & Phillips, of Providence, and cost $1 290.

All iron work was painted with red lead and the floor was given a coating of asphalt composition containing about 20 per cent. of crude petroleum to render it soft and tough. The troughs were filled with clean coarse gravel, over which asphalt was poured to make a firm porous sub-ballast, and upon this filling was placed the broken stone track ballast. A substantial coating of asphalt mastic, two or three inches in thickness, was put over the top of the girders to protect them from abrasion by the track ballast. This waterproofing work cost from $1.95 to $2.50 per square yard

The steel work for this bridge was furnished by the Berlin Iron Bridge Company.

The structure covers an area of about 17 000 sq. ft., the metal weighing 1 794 672 lb., and cost was approximately $2.35 per square foot of surface, exclusive of foundations.

Woonasquatucket River and Promenade Street Bridges. — These bridges are situated at the easterly or northerly end of the new station and carry the 12 tracks in the train shed over the new channel of the Woonasquatucket River and over the extension of Promenade Street. The river is 100 ft. wide and Promenade Street about 74 ft. wide.

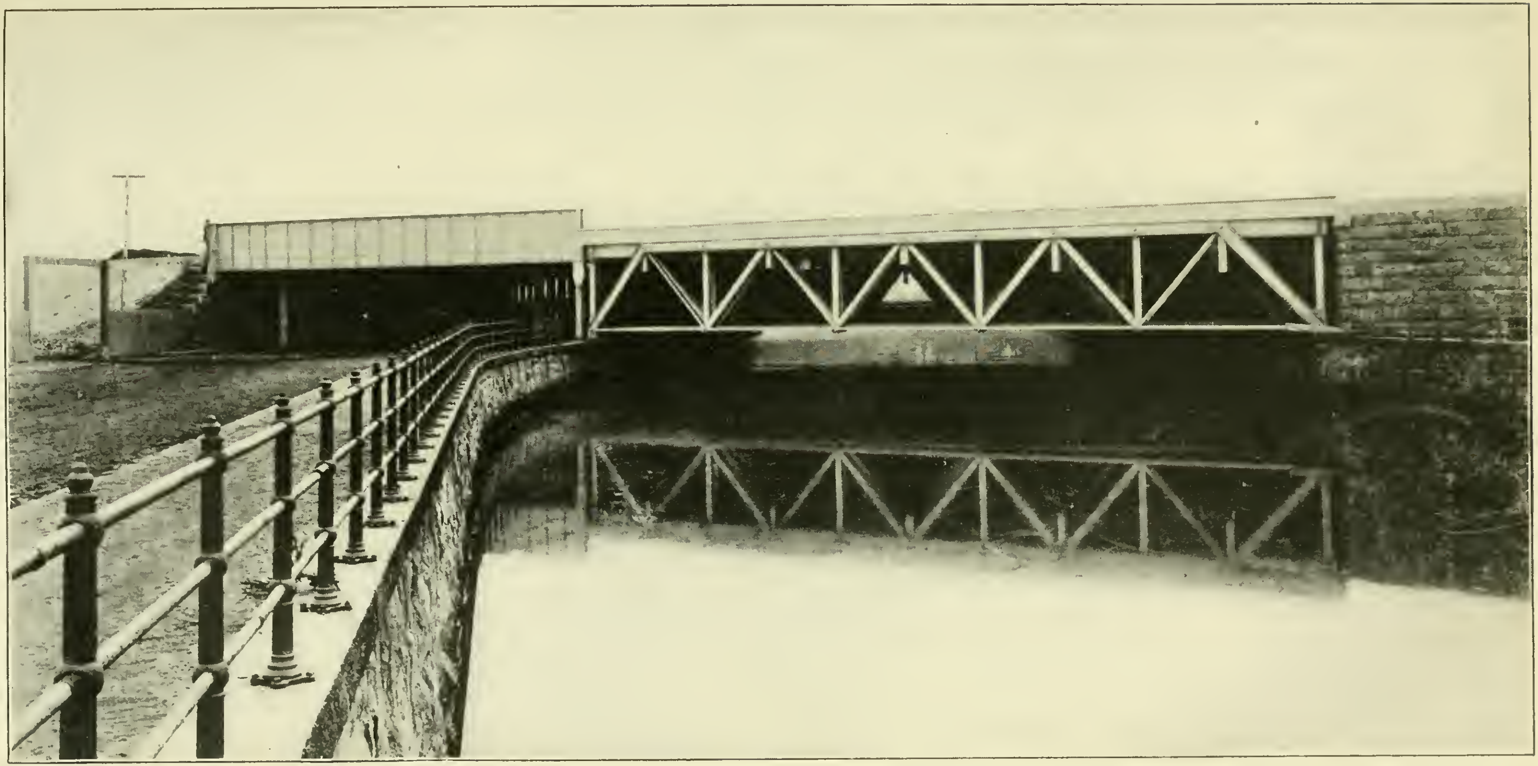
An agreement was entered into between the railroad companies and the city wherein the city agreed to construct "the channel walls of the Woonasquatucket River where the same lie under the tracks entering the new station from the east," the railroad companies to reimburse the city for this work at the same rate that it was paying for the other portions of the walls then being built under their contract with J. J. Newman.

Under this agreement there was built 178 ft. of channel wall on the south side of the river and 230 ft. of channel wall on the north side of the river carried up to a height of 7 ft. above mean high water. These walls rested on a pile and timber foundation, the piles being spruce 40 ft. long, 12-in. butts and 6-in. tips, and were driven until the penetration did not exceed 1 in. per blow for the last 5 ft. with a hammer weighing 1 800 lb. falling 20 ft. or its equivalent. Batter piles were driven on the channel sides to hold the walls from moving forward and riprap was used to some extent in front of them to stiffen the soft material and prevent scouring. The piles were then capped with a three-course platform of hemlock timber 24 in. thick, which was put together in the water and afterwards sunk to proper position over the piles, to the outer row of which it was securely drift bolted with 1-in. blunt bolts 32 in. long. The heads of the piles were cleaned off by a diver before the platforms were sunk.

The face masonry was of coursed quarry-faced work. The specification called for stone from 16 to 30 in. in height, laid alternate header and stretcher with $\frac{3}{4}$-in. vertical and horizontal joints and all beds roughly dressed for their entire length. For about two feet in depth stone was laid in Portland cement mortar, the foundation and backing being laid in Rosendale cement mortar, the latter mixed in proportion of 2 parts sand to 1 part cement.

This work was begun August 15, 1890, and completed May 15, 1892, costing very close to $40 000.

On top of the south or west wall for river channel was built



Woonasquatucket River and Promenade Street Bridging. End View.

up the west abutment, wing-wall, steps, etc., for the Woonasquatucket River bridge. This work, together with the construction of the east abutment and piers for Promenade Street bridge, was done under separate contracts by John T. Tank. Both these abutments are carried up a sufficient height so that they serve as retaining walls for the earth embankment forming the east approach.

The structure over the river was a deck pin-connected truss-bridge. The trusses were mainly arranged square across the river, the end trusses being skewed to the required line of the bridge. A solid flooring of 6-in. hard pine timber was used in place of the metal troughs to effect a saving in initial cost.

The Promenade Street structure was built of box girder construction with solid, watertight, metal flooring similar to that for Gaspee Street bridge. The total length over river and street, from center to center of end bearing, is 195 ft.

Both these structures cover an area of 47 000 sq. ft., Promenade Street bridge weighing about 1 000 tons and Woonasquatucket River bridge about 1 500 tons. The cost per square foot of surface, exclusive of foundations, was approximately $2.38.

The contract for the steel was executed with the Berlin Iron Bridge Company, who sublet the river portion to the Pencoyd Construction Company.

Moshassuck River Bridge. — The course of the old channel of the Moshassuck River, which came directly under the proposed easterly approach, was diverted so that it joined the Woonasquatucket River a short distance below the end of the train shed. That portion of the work underlying the railroad location was done by the railroads under contract with Joseph Ross. It was begun on June 15, 1890, and completed just two years later. The old channel was then filled up. The masonry walls are on pile and timber grillage foundations, similarly designed and constructed to those for Woonasquatucket River, with the exception that no batter piles were used. The cost of building this portion of the river walls, including work done by the railroad in filling the old channel, was about $40 000, of which amount $17 000 was recovered from the city.

The channel is 50 ft. wide and was bridged for 300 ft. in length with twenty-eight heavy box girders spaced 11 ft. center to center, carrying the extension of the freight house and six freight tracks. The solid metal flooring consisted of V-shaped troughs of the Andrews patent. This bridging was furnished by the Boston Bridge Works. The total weight was 1 141 332 lb.

and cost approximately $2.93 per square foot of surface exclusive of foundations.

Francis Street Bridge. — The foundations for this bridge consist of 35 to 40 ft. spruce piles capped with grillage of hemlock timber. The two abutments supporting the track bridging are about 280 ft. long each.

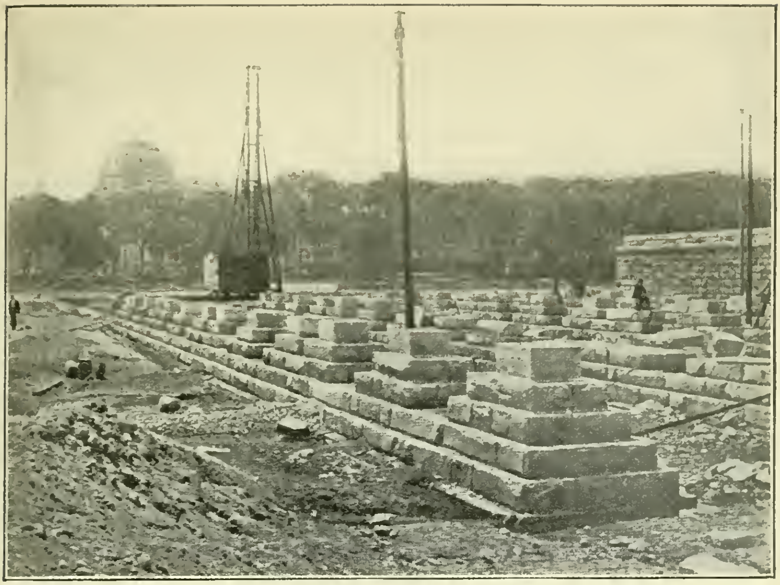
The excavation and timber foundation work for the east abutment and easterly half of the piers was done by F. E. Shaw, who also had the contract for similar work in Francis Street under the station. The masonry in these piers and abutment was furnished by J. T. Tank. The excavation and timber work for the west abutment and westerly half of the piers was done by Ingerson & Daily and the masonry in abutment and piers by Ingerson & Nash.

"The bridge is composed of eleven plate girder spans resting on built-up steel columns of I section, connected by latticed struts. The center span, which extends over part of Francis Street, is 43 ft. center to center; the others are 29 ft. 3 in. center to center and are arranged symmetrically to the street. All the spans are of deck construction, with the single exception of one span about 60 ft. from the street itself on each side of Francis Street, these being half-through spans in order to give necessary head-room for the subways connecting with the platforms and the street below." * The structure is 335 ft. 6 in. long by 202 ft. 6 in. wide and provision was made for ten tracks, between which were located the platforms, light areas and the stairways.

That portion of the bridging in the rear of the station building carrying the tracks and platforms over Francis Street and adjacent thereto was built by the Pennsylvania Steel Company. The weight was 5 065 654 lb. and cost approximately $1.72 per square foot of surface, exclusive of foundations. The bridging which carries the approach street over Francis Street in front of the station and which supports the station building over Francis Street was built by the Boston Bridge Works in 1895.

Smith Street Bridge. — This structure, which originally carried the highway over two tracks, was widened to make provision for six tracks. It is a through truss bridge 95 ft. 2½ in. center to center of bearings, the width of roadway being 46 ft. 6 in., with two 15-ft. sidewalks outside of the main trusses, and has a clear height of 16 ft. 8 in. above tracks. The steel was furnished by the Boston Bridge Works and weighed 509 216 lb. Work was begun April 15, 1890, and finished June 15, 1891, the

* *Engineering News*, January 28, 1897.



Foundation Piers, Francis St. Bridge.

Foundation Piers, Francis St. Bridge.

Francis St. Bridge. Top View of Solid Metal Flooring.

completion of the street work being accomplished a little later. The structure cost very close to $54 000, of which amount one half was charged to the terminal work.

The cost of land for, and the moving over of, Gaspee Street near Smith Street, including fencing and filling, was approximately $45 000.

Track Approaches.

The total length of the new line is about one mile. The station itself has 500 ft. of straight and level track. On the west approach the line is 2 300 ft. long, with a maximum rising grade of about 26.4 ft. per mile (0.5 per cent.); on the east approach it is about 1 600 ft. long, with a rising maximum grade of about 38.8 ft. per mile (0.735 per cent.). The approach curves immediately at the station are 9 degrees. The track approaches were built on embankments having a maximum rise of about 10 ft. above the point where the new grade left the existing tracks. There were no walls designed to sustain the embankment.

The filling for the westerly approach was brought from the vicinity of Roger Williams Park, where a tract of land of about five acres was bought for the purpose and where the removal of material made practicable the reduction of a 6-degree curve on the main line to a 2-degree curve. About 100 000 cu. yd. were used in making this fill, the work being done by the railroad.

A portion of the filling for the easterly approach was taken from the old site of the Sans Souci Garden, between Broadway and Atwells Avenue, about opposite Jackson Street. This high bluff was removed by team under contract with Frank Slavin.

The remainder of the filling required for this approach came from the Horton Street Yard of the Old Colony Railroad between Northup and Smithfield avenues.

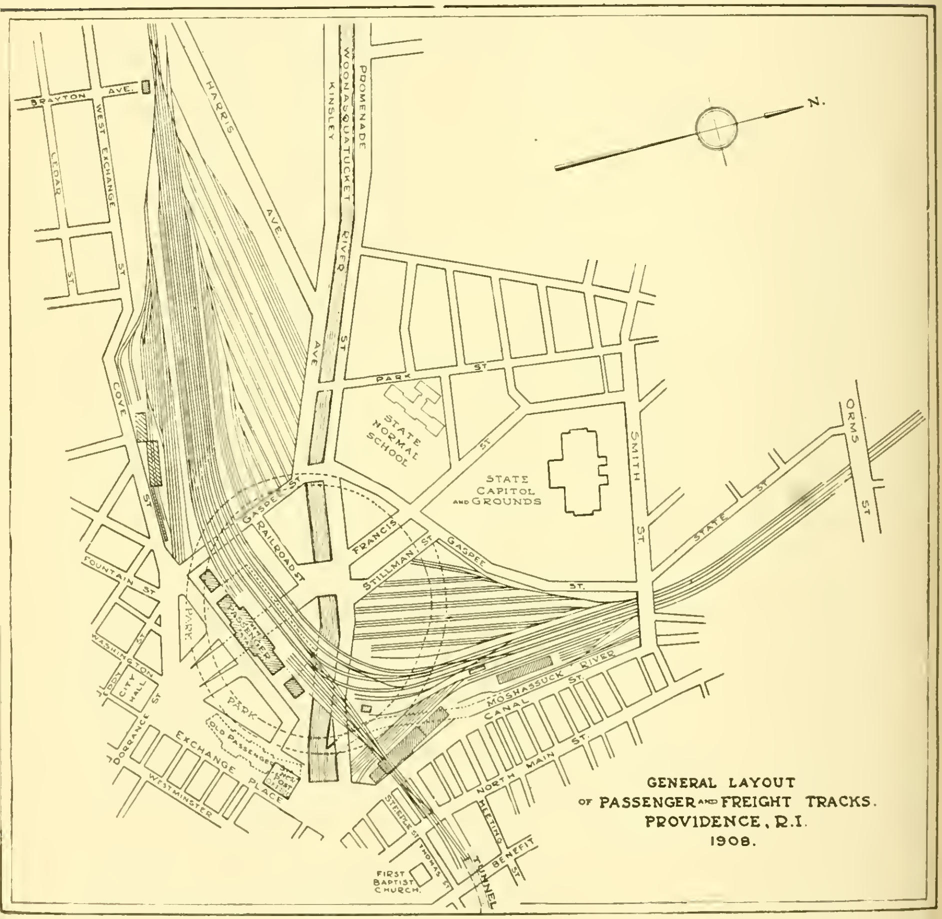
Tracks.

The track layout, which is "one of the most important essentials of a railway," and particularly of its terminal facilities, received most careful study.

Fourteen tracks were provided in the station; eight of these (four at each end) were stub-end tracks for suburban business and lay nearest to the main waiting room, so that access to trains from the main concourse might be had without the necessity of using the subways. Passengers holding commutation tickets may reach the platforms serving these tracks by passing through the colonnades on the right and left of the main building, without

entering the waiting room, thus relieving possible congestion during rush hours.

Four through tracks were provided for passenger traffic which were under train-shed protection and two through tracks in the rear of the train shed for freight. Provision was made,



when the foundations were built, for the future installation of two additional tracks in the rear of the station, to which, when the exigencies of operation demanded, the freight service could be transferred, leaving the fourteen tracks in the station for the exclusive use of passenger service. The bridging to carry these two additional tracks was also erected with the exception of the spans across Francis Street.

The tracks were laid in pairs on 12-ft. centers. The distance between adjacent tracks of each pair was 30 ft. center to center, which gave platforms about 20 ft. wide.

On the north approach, at Smith Street, tracks were arranged so that leads into the Canal Street yard and the yard on Promenade Street were from separate tracks, thus leaving the four main tracks free from switching movements.

On the north and on the west approach, double diamond cross-overs, with nine double slip switches, properly interlocked, made it possible to pass trains from any main track to any station track or vice versa.

Rails. — The rail used throughout the terminal was the New York, New Haven & Hartford Railroad standard 100 lb. to the yard, $5\frac{1}{2}$-in. base, $2\frac{3}{4}$-in. head and 6 in. in height.

Frogs and Switches. — All the regular turnout switches had 15-ft. points, and No. 8 frogs were used generally. All slip crossings were provided with movable point frogs, while the frogs used elsewhere were of the rigid bolted type. Guard rails were 10 ft. long.

Ties. — Standard ties 7 in. by 9 in. by 8 ft. long, mostly of chestnut and oak, were laid on a first quality screened gravel ballast.

Bumping Posts. — Ellis patent bumping posts, all equipped with the standard 100-lb. rail, were provided for all stub-end tracks in the station.

Standpipes. — Two Fairbanks and Morse 8-in. standpipes, direct connected to the city water supply, were provided, one for the east and one for the west bound through tracks.

Fencing.

The midway fence was of round pickets 8 ft. high and finished in the natural wood. The gates were provided with overhead bearings and rolled back on the fence, leaving openings 8 ft. in width.

Fencing between tracks was $4\frac{1}{2}$ ft. high, built of $1\frac{1}{4}$-in. square pickets and so arranged between each pair of tracks that crossing at grade by passengers was prohibited. Sliding gates were built at convenient points to be used exclusively in trucking of baggage and express matter.

The fencing between office building and restaurant building, and between the express building and baggage buildings, also at the east end of the express building, was of wrought-iron with heavy uprights for posts $1\frac{3}{4}$ in. square, set deeply into the granite

and thoroughly tamped with lead. Sliding gates with overhead bearings and anti-friction rollers were provided.

Platforms.

All platforms are of wood and follow the general steam railroad practise, being constructed on a level with the top of rail. The edge of platforms is 24 in. from gage of rail. The platforms are generally 20 ft. in width, and those serving the through tracks were provided with stairways to the subways.

Freight Facilities.

Not the least of the changes contemplated by improved terminal facilities was adequate provision for freight. Large yards were built on the east and west of the station site, with ample street approaches and within reasonable proximity to the business part of the city.

Promenade Street Yard. — This yard was for carload or bulk freight. It fronts on Promenade Street and comprises an area of about ten acres, containing twenty-two tracks arranged in groups of three, ranging from 400 to 1 600 ft. in length. It had a capacity of 439 cars, about 70 per cent. being accessible to teams, the balance being used for storage. The tracks were laid on 12-ft. centers with 35-ft. driveways.

A 30-ton overhead bridge crane, built by Brown Hoisting and Conveying Company, was put in for the speedy and safe handling of heavy freight. Ample fire protection, by means of hydrants connected with the city system, was also provided, and the entire property enclosed by a substantial fence.

Gaspee Street and Kinsley Avenue Yard. — Another yard for bulk freight was built on land acquired from the city lying north of the former New England Railroad location on Gaspee Street and had a frontage on that street and Kinsley Avenue. The tract comprised an area of over 15 acres, on which there were laid 26 tracks having a capacity of 675 cars. There were nine driveways between tracks, which were laid in pairs on 12-ft. centers, the distance between centers of adjacent tracks being 48 ft.

West Exchange Street Yard. — This was the former freight terminal of the New York, Providence & Boston Railroad. The old freight house was extended and the track arrangement remodeled and the capacity considerably increased. The freight house was made 680 ft. in length; for 300 ft. the width was 20 ft., and the remainder of the length it was 50 ft. in width. On the

New Highways.

Name of Street.	Between What Points.	Width of Street.	Length in Feet.	Character of Paving.
Francis Street	Gaspee Street to Railroad Street	80	1 477	Granite blocks on concrete base.
	Railroad Street to Exchange Place	100		
Stillman Street	Gaspee Street to Promenade Street	60	546	Granite blocks on concrete base.
Railroad Street	Gaspee Street to Francis Street	60	423	Granite blocks on concrete base.
Gaspee Street (relocation)	Smith Street to second angle south	60	1 030	Granite blocks on concrete base.
Promenade Street	Gaspee Street to Railroad Bridge	80	1 405	Granite blocks on broken stone foundation.
	Railroad Bridge to near Canal Street	70		Granite blacks on concrete base.
East Approach	Exchange Street to center of station	80	665	Asphalt on concrete base.
West Approach	Gaspee Street to center of station	80	460	Asphalt on concrete base.
Exchange Street	Exchange Place to East Approach	70	174	Asphalt on concrete base.
Exchange Place	Washington Street extension from Dorrance Street to near Canal Street		1 240	Asphalt on concrete base.
	Exchange Place to Station, Approach to Station on east side of Francis Street	70	308	Asphalt on concrete base.
	Exchange Place to Station, Approach to Station on west side of Francis Street	70	286	Asphalt on concrete base.
Harris Avenue (relocation)	Acorn Street to Kinsley Avenue	60	2 327	Granite blocks on concrete base.
Gaspee Street	Kinsley Avenue to West Exchange Street	70	764	Granite blocks on concrete base.

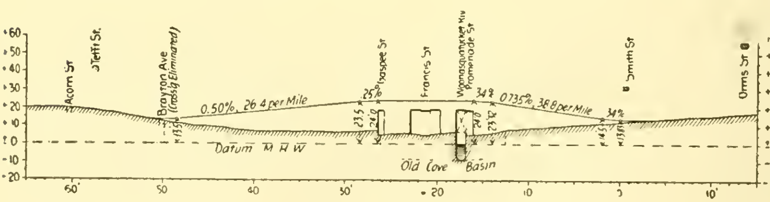
West Exchange Street side forty-one receiving doors were provided. There were 720 ft. of covered platform having a width of 12 ft. The capacity of the yard was 356 cars.

Canal Street Yard. — The freight terminals of the old Boston & Providence Railroad and the Providence & Worcester Railroad were situated along Canal Street. Under the new arrangement all outward freight is now received at the house of the former road and all inward freight is delivered at the house of the latter road. Two new iron sheds were built in extension of the Providence & Worcester Railroad house, aggregating 225 ft. in length and having a width of 60 ft. A platform from 15 to 20 ft. in width extends the entire length of the house on the track side. A covered platform 20 ft. by 300 ft. was built to connect this house with that of the Boston & Providence Railroad.

The freight house of the Boston & Providence Railroad was 70 ft. by 300 ft. with an 8-ft. platform on the track side. At the extreme east end of the house an extension platform 25 ft. by 221 ft. was built. The yard had a capacity of 160 cars.

Station Buildings.

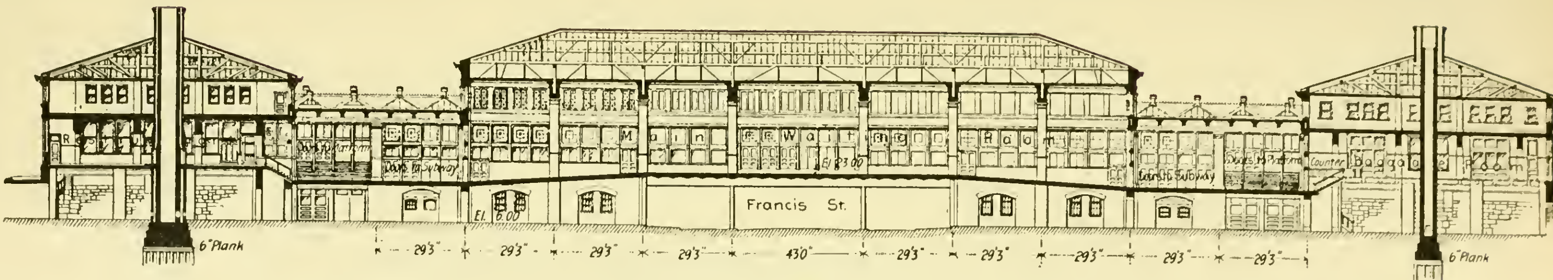
The station is of the Renaissance style of architecture and is divided into groups, there being five separate buildings.



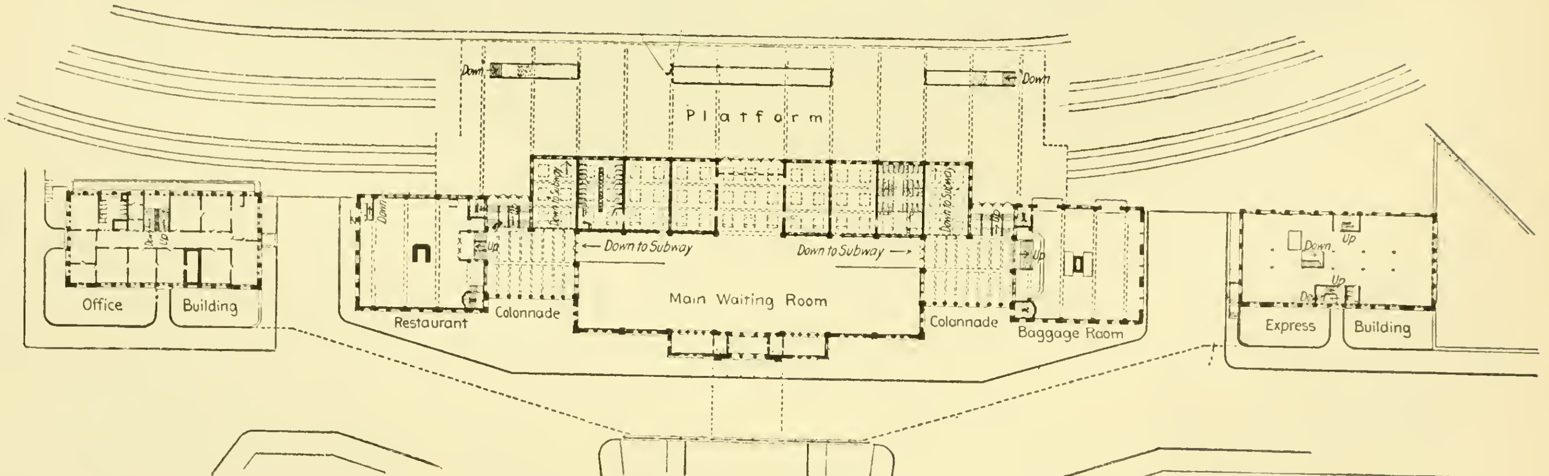
-PROFILE OF NEW TERMINAL

Three of these are connected by colonnades or roofed passageways and form the station proper. The central building is 220 by 110 ft., one story high and contains the waiting room, toilet rooms, ticket offices, cab office, etc. On each side and connected with this central building by a colonnade, having a roof supported by columns of polished granite, is a building 72 ft. by 84 ft., two stories high. The one on the east is for baggage and the one on the west for a restaurant. In the middle of the street front of the main building is a low heavy tower with a porte-cochère in front of the main entrance.

To the right and left of the station proper are two separate four-story buildings, 125 by 65 ft., the one on the right being



LONGITUDINAL SECTION THROUGH WAITING ROOM, RESTAURANT, BAGGAGE ROOM AND COLONNADES.



-FIRST FLOOR PLAN OF STATION BUILDINGS, PROVIDENCE, R. I.

for express service and freight offices and the one on the left being a railroad office building.

The total length of the group of buildings is 870 ft. and the width is from 65 to 110 ft.

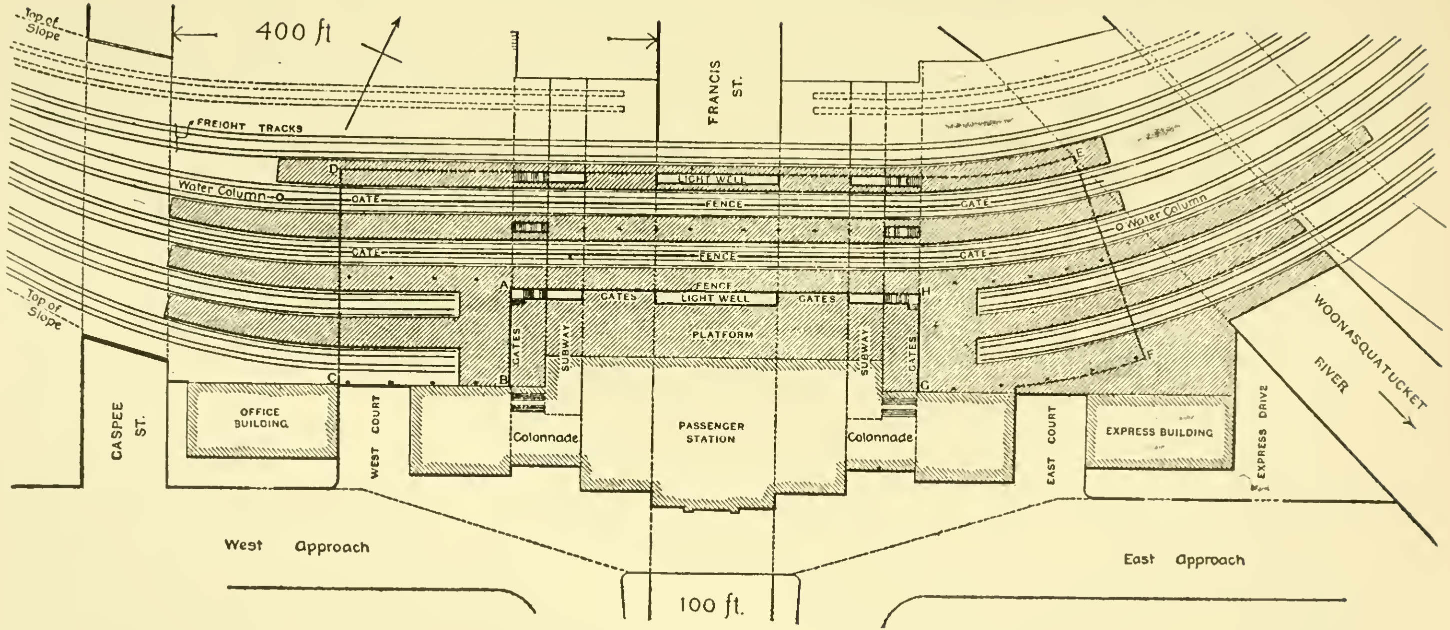
Foundations. — The buildings are on pile foundations. The piles used were spruce 40 to 45 ft. long and driven in double and triple rows under the walls, with a spacing of 30 to 36 in. on centers. The loading generally was about 8 tons per pile. The material through which they were driven was so soft as to necessitate horizontal timber struts or braces to prevent lateral movement. The piles were cut off at elevation 4.50 ft. below high tide, the low tide level being 4.85 ft. below high tide. The cost per pile in place was $4.24 for the main building and $3.98 for the express and office buildings.

All piles were capped with 12 in. by 12 in. timber with a close flooring of hemlock plank 6 in. thick in ordinary cases and 8 in. thick under heavy masonry. There were about 4 000 piles in this foundation work. Upon this substructure were built foundation walls of granite rubble masonry. J. T. Tank was the contractor for the main station building foundations, including the baggage and restaurant portions, and Joseph Ross the contractor for foundations for the express and office buildings.

Superstructure. — Upon the foundations thus prepared was erected a superstructure of mottled yellow brick, trimmed with Connecticut Valley red sandstone from Longmeadow, Mass.

The roofs were covered with 16-oz. sheet copper, while 18-oz. copper was used for the gutters. The concourse shelter attached to the track side of the station building was also covered with copper, there being something over three acres of copper roofing in all.

The main waiting room floor, including the inclines leading to the colonnades and subways, and also the incline leading to train platform and the floor of the front vestibule, were of concrete, with thrown marble mosaic covering. This covering was laid without pattern in the center, but had an 18-in. border of colored marbles laid to line and geometrical pattern in the main waiting room and 12-in. border in the restaurant. The floors of all water closets, in the office building, in the central building, in the baggage building and in the express building were of granolithic, while that of the colonnades and the two inclines leading to subways was of Trinidad asphalt. In the smoking room and women's room the flooring was finished in 2½ in.



Plan of New Passenger Station and Train Shed

tongued and grooved, long leaf, Georgia hard pine, close laid and blind nailed to strips embedded in concrete.

A portion of the walls of the colonnades; the walls exposed to view on three sides of the inclines from colonnades to the subways; both sides of the inclines from colonnades to waiting room; the four sides of the main waiting room to the window sills and between window sills for a height of 6 ft.; the walls of the lavatories; the walls of the restaurant up to the windows and between them for a height of 6 ft., were all finished in white enameled brick.

The interior finish of walls in men's and women's rooms consisted of high wainscoting of paneled red oak, above which, to the ceiling, they were plastered and walls calcimined. The ceilings of all buildings were covered with first quality stamped steel of neat design and painted two coats of pure white lead paint in addition to the priming coat. The partitions between vestibules and main waiting room, between men's room and women's room, the men's lavatory and women's lavatory and the main waiting room; also partitions forming the rear vestibule and entrance to train platform, were finished with red oak.

In the office and express buildings the columns and main floor girders were of steel and the inner partition walls of brick, while the floors were of slow-burning mill construction, with hard pine beams and mineral wool packing between these beams and the double floors. Brick vaults and safes, each furnished with a set of Corliss fireproof doors, were provided on each floor of the office building.

The ground floor areas of the various buildings were as follows:

Central building	25 500 sq. ft.
Restaurant building	5 900 sq. ft.
Baggage building	5 900 sq. ft.
Office building	7 500 sq. ft.
Express building	7 500 sq. ft.

The main waiting room was 218 by 60 ft., the restaurant and baggage rooms each 70 by 70 ft.

Persons entering the station at the colonnades can go directly to the main platform by the steps or to the outer platforms by means of the inclines to the subways. They can enter the baggage room or restaurant by the steps or enter the main waiting room by the side doors and the inclines. Persons in the main waiting room can go directly out on to the main platform or to the stairways leading to the subways.

Porte-Cochère. — The central entrance was protected by a glass roof which covered the entire street in front of the station, a space about 60 by 100 ft., affording ample shelter for passengers arriving or leaving by carriages. The street railway company subsequently enlarged this shelter to cover tracks laid by them in front of the main entrance.

Concourse. — The concourse is 335 ft. long and varies in width from 55 ft. to 100 ft. It has a total area of about 19 000 sq. ft. and was laid in concrete with granolithic top finish.

Passenger Subways. — There are two main subways under the platforms and tracks, running transversely to the station, parallel with Francis Street. Access to and egress from these subways is had by easy inclines of about 6 per cent. grade from the main waiting room on the right and left; from the streets in front of the station, through the colonnades; by stairways from Francis Street under the station or by stairways at either end of the main concourse. Passengers are thus enabled to reach any train in the station without crossing a track at grade and without necessarily passing through the main waiting room.

These subways were built 30 ft. in width, had a clear height of 7 ft. 3 in. and extended the full width of the station layout, a distance of about 275 ft. Four stairways lead up from each subway to the platforms serving the through tracks. They were built 8 ft. 3 in. in width and the 19 steps required had 6-in. risers and 13-in. treads, with two intermediate landings. The stairway openings in the platforms, although under train-shed protection, were housed over with a light wooden frame structure, as a further protection of these passageways from winter winds to which the north side of the station platforms are exposed. Small telephone booths were built at one end of two of these shelters by extending them 4 or 5 ft., thus affording train men convenience and dispatch in communicating with the station master's office, with which they were direct connected.

Inclines. — The use of inclines to avoid steps was quite extensively applied on this terminal work and illustrates very fully the adaptation of this principle.

To obviate the necessity of steps from the main waiting room to the subways, and to secure the easy grade desired, this room was placed at 2 ft. lower elevation than the track platform and this difference was overcome by an incline which is hardly noticeable, between the waiting room and the main concourse.

The distance from the subways to track level is 10 ft., and this was overcome by stairways having 19 steps; these are the

only steps required to be taken by a passenger in reaching any train in the station.

Mechanical and Electrical Apparatus. — The buildings are heated by hot-air system and lighted by electricity. In the basement of the restaurant building there was installed a battery of four 72-in. boilers, 18 ft. long, aggregating 500 h. p., which furnished steam for heating and operating the electric light plant. The steam pipes from the boilers heat the several air intake chambers, and from these chambers extend the air ducts. The fresh air is discharged through registers, located near the floor level, in the various rooms and the vitiated air drawn off by exhaust pipes near the ceiling. The steam pipes, etc., are connected between the several buildings through subways or tunnels and also pass over Francis Street in an overhead passage or pipeway concealed in the thickness of the bridge girders. The fans for circulating the heated air may be driven by steam or electric power.

Provision is made for the delivery of coal into the boiler room on the track side by means of chutes so arranged that it can be shoveled directly from the cars; or on the street level by means of teams which can be driven into the basement.

Minor Station Conveniences. — Cab office. Telegraph office. Station master's office. Barber shop. Lunch counter. Lunch counter serving room. Telephone booths in station. Telephone booths on concourse and outer platforms. News stand. Flower booth. Candy and fruit booth. Soda fountain booth. Parcel room. Bootblack stand. Quarters for trainmen. Quarters for station porters.

Service Tracks. — To facilitate the work of foundation and bridge construction an extensive system of service tracks was laid over the site, and this resulted in reducing the contract prices, as all material was delivered on cars at the site of the work at points where it could be handled directly by derricks.

The architects of the station were Messrs Stone, Carpenter & Willson, of Providence, R. I., and the building work above foundations was done by Horton & Hemenway, of Boston, Mass. The building, including foundations, heating and lighting, cost about $570 000, or approximately 18 cents per cubic foot.

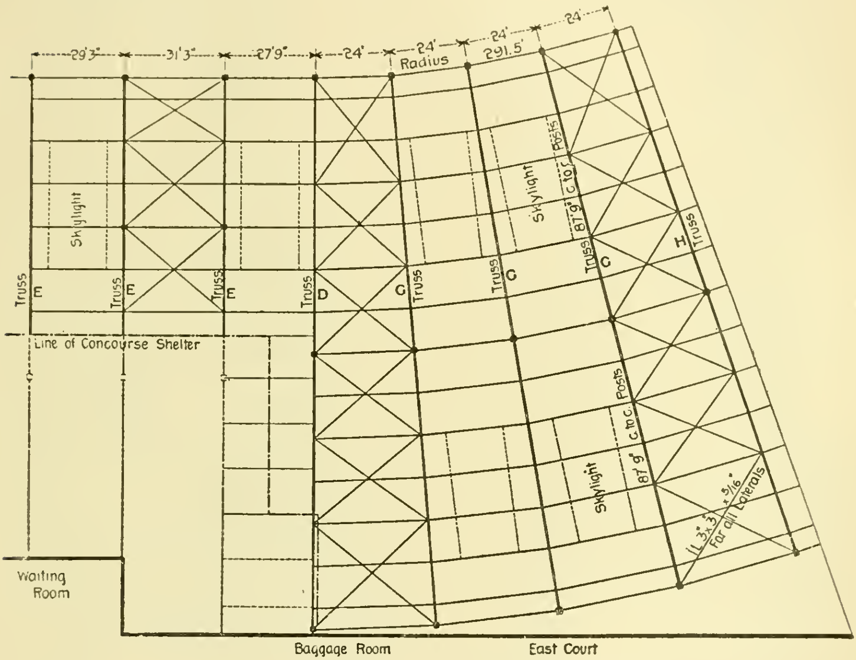
The work on superstructure was begun in the early part of 1896 and completed in the fall of the following year, but owing to controversy over the question of train-shed provision, the opening of the station was delayed until September 18, 1898.

Front View, Present Union Passenger Station.

Train Shed and Express Building, Providence Station.

Train Shed.

The main station building, approaches, track, etc., were completed in the fall of 1897, but the railroad was restrained from operation of its new terminal facilities owing to the fact that a controversy had arisen between the officials of the city and of the railroad company as to the style and sufficiency of train-shed accommodations. Up to this time only the concourse had been

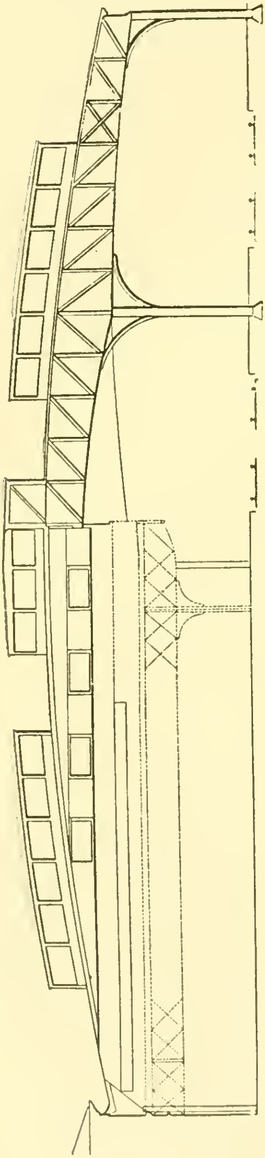


Part Plan of Providence Train Shed.

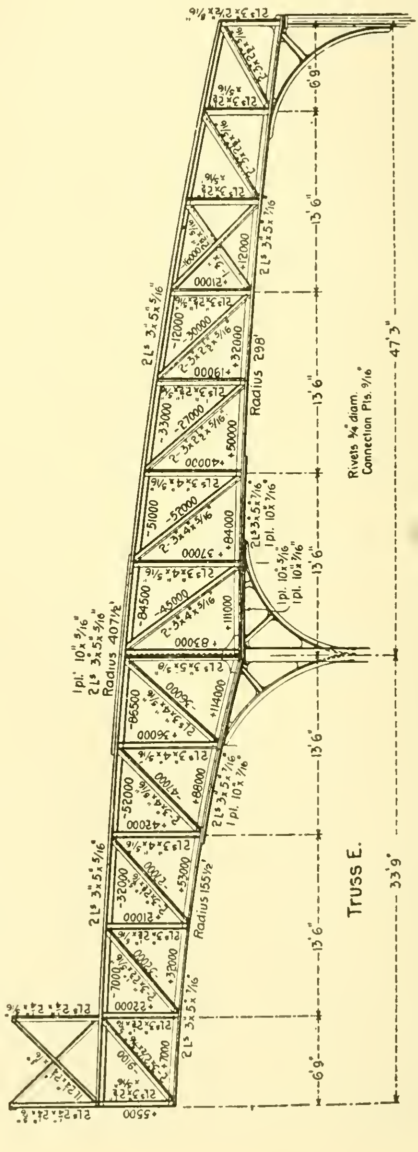
protected by shelter, it being the desire and purpose of the railroad to study the local needs from actual operation before constructing an elaborate train shed. To this the city would not agree, and an injunction from the courts was secured to prevent the use of the station by the railroads. In the conferences which followed various plans were brought forward by both parties only to be rejected as inadequate or inharmonious with the general layout. The writer, who was then at the Boston Terminal, suggested a plan, as a solution of the difficulty, to President Chas. P. Clark, who said that he would build such a train shed if the city's approval could be secured, and the writer was authorized to negotiate with the city authorities to this end. The plan was

submitted to the Joint Special Committee on Train Shed and by them recommended to the city council and was unanimously adopted at their meeting March 7, 1898.

The shelter which had been built over the concourse, protecting the entrance to the station on the track side, was allowed to stand, and around this structure the new train-shed was built.



Transverse Section Near West Side of Concourse.



Cantilever Truss

"The end view of the train shed shows two roof spans of 87 ft. 9 in. each, or a total width of 175 ft. center to center of supporting columns and a little less than 180 ft. extreme width. The width opposite waiting room is 153 ft. The least clear height above tracks is 21 ft. The height to top of monitors on center line of structure is 40 ft. The length on the center line of the shed is 640 ft. Of this length, for 360 ft. (in the center) the roof trusses are of a cantilever construction, having an unsupported bracket projection one side of column of 34 ft., forming an 'umbrella' about 70 ft. wide and leaving to be supported by the rear (northernmost) columns practically less than 10 ft. in width of roof. Such an arrangement was feasible and desirable in this instance, as there was ample supporting strength in the underlying iron work of Francis Street Bridge (upon top of which this part of the train shed was built), where the 'umbrella handle' comes, and not such ample supporting strength in the underlying work below the rear columns. These rear columns, therefore, render their most important service by giving lateral stability. Where the truss roof was broken off, at the junction with the existing roof of the concourse, vertical wooden construction was used with the necessary windows to furnish light and shut out the rain. The vertical wood construction gives an apparent, but not real, support to the ends of the cantilever trusses.

"Light and ventilation were provided at the top of the main shed, both by a continuous lengthwise monitor along the crest line and by thirteen cross monitors distributed over the roof. On the roof boards was laid a first-class gravel roof with copper flashings, gutter strips, etc." *

Cost of Train Shed.

Area covered	75 000 sq. ft.
Weight of steel per square foot	17 lb.
Cost of steel work, including covering and monitors, but not including foundations	$48 000
Cost per square foot exclusive of foundations	64 cents
If the cost of foundations is added, the total cost would be approximately	$1.00 per sq. ft.

This compares favorably with cost of train sheds at other large terminal stations, as follows:

Pennsylvania Railroad, Jersey City	$1.07 per sq. ft.
St. Louis Terminal	1.00 per sq. ft.
South Terminal Station, Boston, Mass.	1.11 per sq. ft.
Reading Terminal, Philadelphia	1.15 per sq. ft.

(Foundations are included in cost in each of above instances.)

* *Railroad Gazette*, August 5, 1898.

Engineers.

Mr. E. P. Dawley, chief engineer, represented the interests of the New York, Providence & Boston Railroad and the Providence & Worcester Railroad.

Mr. S. L. Minot, chief engineer, represented the interests of the Boston & Providence Railroad and later its lessor, the Old Colony Railroad. His place was subsequently filled by Mr. J. W. Ellis, who held the position until the lease of the Old Colony Railroad by the New York, New Haven & Hartford Railroad.

Subsequently to the control by the New York, New Haven & Hartford Railroad of the various properties, Mr. F. S. Curtis, chief engineer of that road, had general engineering oversight of the entire construction.

The writer, who was principal assistant engineer, New York, Providence & Boston Railroad (in the engineering department of which the terminal scheme, as substantially carried out, originated and the plans and estimates were prepared), was in March, 1892, made resident engineer, and retained that position until July 1, 1896.

Mr. A. B. Corthell was principal assistant engineer during the period of construction.

Four-Track Work.

The work of four-tracking the road between Providence and Pawtucket, a distance of about four miles, was a part of the general scheme of improved terminal facilities. This work entailed the widening of a deep cut through Smith's Hill; the building of heavy retaining walls; the reconstruction of several highway bridges; replacing wooden structures of low head room and posts between tracks with steel bridges of single span and good clearance (provision being made for four tracks and in some instances six tracks, in place of two existing); the abolition of all grade crossings; the installation of the latest and most approved interlocking and signaling apparatus.

Grade Crossings. — A very dangerous grade crossing existed at Charles Street, over which a large amount of teaming was done for twelve hours in the day. Plans for its abolition provided for carrying the highway over the tracks by a through truss bridge, with short easy grade approaches, about 3 per cent., on each side. The tracks were depressed $1\frac{1}{2}$ ft. and the street raised about 19 ft., giving a clearance of 18 ft. above the top of rail. The bridge is 122 ft. long, spanning five tracks, the trusses

being 50 ft. center to center of posts. Work was begun November 15, 1891, and finished December 1, 1892.

A grade crossing at Webster Street and an underneath crossing at Northup Avenue were also abolished.

Bridging. — A new highway bridge was erected at Chalkstone Avenue carrying the 40-ft. street on ballast floor and consisted of two through riveted trusses having spans of 80 ft. 6 in. center to center of bearings.

All other bridges on this section were of sufficient span to permit of four tracks being laid.

Interlocking and Signaling. — At Orms Street a mechanical plant, of 35 working lever capacity, was installed controlling the double crossovers and slip switches. This location marks the southern or western terminus of the main four tracks and the beginning of the north approach to the Union Station.

Another important improvement was the change to running "right handed," which went into effect Sunday, October 22, 1895. Originally the roads entering Providence from the east followed the English custom of running "left handed" over this section between Providence and Pawtucket, operated jointly by the Providence & Worcester Railroad and the Boston & Providence Railroad, and known as "The First Division."

Operation. — This four-track work was begun April 15, 1890. The third track was completed and put in service February 4, 1892, and the fourth track was completed and put in service May 8, 1892.

Burning of the Old Station.

In the early morning hours of February 21, 1896, fire was discovered in the old station building, and before it was extinguished the interior of the building, especially the central portion, used almost wholly for passengers, was completely gutted.

This station building was erected in 1847-8 and was, at that time, considered to be the handsomest as well as one of the largest passenger station buildings in the United States. It undoubtedly owed its long life, nearly fifty years, to the fact that the stub-tracks and the one through track were so arranged that it was unnecessary for passengers to cross any track at grade. This absence of grade crossings made it a safe station until it was thoroughly outgrown.

After the fire the station was repaired in a temporary manner and used until the new station was opened on September 18, 1898.

ACKNOWLEDGMENTS.

In conclusion, the writer wishes to express his appreciation and thanks to all those engineers and contractors by whose courtesy access to plans and data in their private records has made possible the verifying of many details of the construction work, and especially to Herbert E. Sherman for a copy of the Doyle Plan and to E. H. Howard for a copy of the Compromise Plan. The writer is also indebted to the *Engineering News* for permission to reproduce the plans and sections of the terminal station building and to the *Railroad Gazette* for like courtesy regarding the details of the train shed.

[NOTE. — Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by August 15, 1909, for publication in a subsequent number of the JOURNAL.]

THE EAST SIDE TUNNEL AND ITS APPROACHES, PROVIDENCE, R. I.

By Edwin P. Dawley, Member American Society Civil Engineers.

The Project. — For over thirty years various projects have been considered for a practicable railroad connection for Fox Point, India Point and East Providence, with a union passenger station in Providence that would give a more convenient and commodious terminal for the important traffic on the eastern shores of Narragansett Bay from such centers as Warren, Bristol, Fall River and Newport. It was one of the important problems considered in the general scheme of improved terminal facilities at Providence, and the last link to be forged in the chain of construction that makes a complete union station.

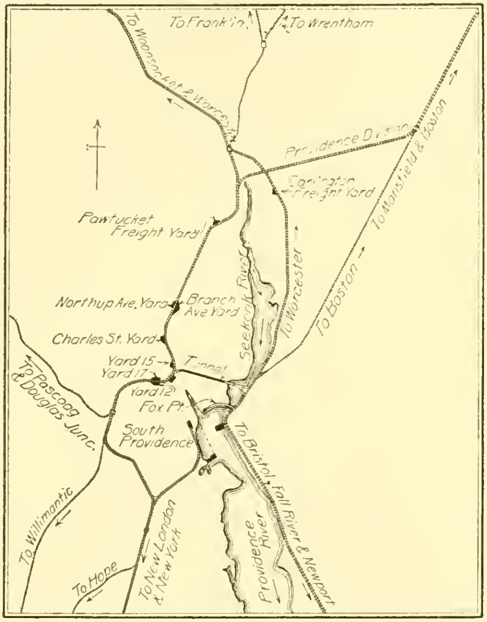
All of the various projects suggested were either too roundabout or too costly at the time for the one or two purposes which they would only inadequately have served. One such scheme, considered as far back as 1875, contemplated crossing the Seekonk River at Walker's Point, about half a mile above the highway crossing known as Red Bridge, and joining the main line of the railroads from Providence to Boston and Worcester at a point nearly two miles from the union station, the distance from Watchomoket Square in East Providence to the union station by this route being 7.75 miles, as compared with 2 miles by the East Side tunnel line.

Another route was by way of an elevated railroad from India Point, through South Water Street, crossing Market Square and Exchange Place near the present site of the new post-office and fire station, and entering the union station over Woonasquatucket River and Promenade Street bridges, just easterly of the station, which bridging when built was designed for such a future possibility. It was estimated that this route, which was approximately a mile long, would cost over a million dollars to construct.

A tunnel route was devised and advocated by the writer in 1894, but to the factor of large cost was added the undesirable operating features contingent upon steam locomotive service. In the light of present experience, it seems extremely fortunate both for the railroad and the community interests, that none of the earlier station projects with stub-end station buildings, and none of the projects with station located a quarter of a mile

further from the center of the city, and none that kept the tracks at a low grade with streets passing over the tracks, was adopted. Any of these projects would have been fatal to the construction of the present East Side tunnel.

The consolidation of the various railroad interests under one strong control, and the many advantages accruing from a tunnel over any other route, resulted in the reconsideration of the project on the broadest lines, giving due importance to present and future values and advantages; while the demonstration of the practicability of heavy electric traction has relieved the tunnel project of strong objections that might have been made against it some years earlier.



The new East Side tunnel, as constructed, while as costly as any of the earlier projects, was justified by the larger number of uses it will now serve. The general growth of population and business has, of course, helped materially to warrant carrying out what would have been too ambitious a project twenty years earlier.

Benefits Derived. — Some of the purposes which the new line can serve, and which, taken together, so well warrant its construction, may be summarized as follows:

First. All the railroad traffic from Newport, Fall River, Bristol, Warren and the entire east shore of Narragansett Bay can be brought directly into the center of Providence, thus making possible direct, all-rail connection to New York, and avoid former delay of transferring across the city from the station at Fox Point to the Union Station. The income from this service alone will to-day probably pay three quarters of the fixed charges on the required expenditure, and in five years the natural increase should take care of all fixed charges.

Second. A new short connection between the east and west side of Providence Harbor. The distance from the center of Providence to East Providence by the new line is 2 miles, as compared with 12.5 miles via Valley Falls, heretofore the shortest rail connection.

Third. A valuable new connection for both through passenger and freight business between Providence and Boston. The line gives opportunity for an additional double-track railroad from the union station, Providence, to East Junction, a distance of 9 miles, there joining former double track line from Providence through Pawtucket. To provide two additional tracks on this former line, between the same points, would probably cost $2 000 000. While such an outlay is not imperatively required for some years to come, a present expenditure of perhaps one third to one half such a sum toward the new East Side tunnel line may be considered warranted by the advantages offered for a new alternate Providence-Boston line.

Fourth. A good alternate line, in case of any blockade on old line between Providence and Pawtucket for all business from Worcester, Franklin, Boston and Taunton to Providence.

Fifth. A new, short, direct, convenient connection to the business center of Providence for both freight and passenger business for about 40 sq. miles of adjacent territory, naturally well fitted for manufacturing interests which just such a rail connection is sure to promote.

Sixth. The easier conduct of the heavy freight traffic now carried on along India Street, Providence, in connection with the several steamship lines to New York, Philadelphia, Norfolk and Baltimore. The removal of the very frequent passenger train service now carried on over a two-track drawbridge, in common with this freight traffic along India Street, will help out the freight work as much as it could otherwise be helped by the expenditure of nearly $100 000.

In the foregoing statement little stress is laid upon prospective future increase. There are also several important services of a secondary nature included in and growing out of the six main items named that should within the next eight or ten years prove of one quarter to one third as much additional value as those specifically enumerated.

To summarize the general business warrant for this important piece of recent New England railroad construction, there is an immediate, mutual benefit accruing to both the interests of the communities served and the railroad that serves them; and

an important link has been added to the railroad system of this vicinity that should have a very great influence upon early future advancement.

Legal and Right-of-Way Matters.

Legislation. — Under the enabling act of the Rhode Island Legislature, passed early in 1904, the "location, layout and construction" of the new line had to be commenced on or before May 15, 1906, and the line completed on or before May 15, 1909. In addition to the usual general provisions in railroad charters in Rhode Island, certain special provisions were made, some of which may be of interest.

The title of the enabling act is as follows:

"An Act in amendment of and in addition to an Act entitled 'An Act to incorporate the New York, Providence and Boston and Old Colony Railroad Terminal Company,' passed by the General Assembly at its May session, A.D. 1891."

Section 4 of said act provides that "said tunnel shall be so located and constructed as not to interfere with the construction of any tunnel which shall have been theretofore authorized and approved by the city of Providence to secure better access to that portion of the said city lying easterly of North Main Street, Market Square and South Main Street, nor to impair the efficiency of any gas pipes, water pipes, sewers or conduits of any nature."

This provision with reference to interference with any tunnel that the city might desire to build proved academic, as no such tunnel was authorized. As a matter of fact there could be no practical interference with such a tunnel, which can readily be constructed at any future time.

Sections 16, 18 and 21 of the act are also quoted as containing special provisions of interest.

"Sect. 16. Nothing in this act shall authorize said company to condemn any portion of the location of any street railway company, or the surface of any highway, except for the purpose of crossing the same either above or below grade, and of maintaining suitable and convenient abutments and other supports for the structures erected or constructed for such crossing, nor to cross any highway or the tracks of any street railway company at grade."

"Sect. 18. The tunnel authorized by this act shall be so built and at all times kept in such condition that the surface of the ground above the same and in the neighborhood thereof shall not thereby be rendered infirm or unsafe for buildings thereon, and any failure of said company in this respect shall

render it liable for damages to be recovered in an action of the case."

"SECT. 21. If said company shall fail to begin the location, layout, and construction of its said railroad as provided by Section 3 of this act on or before May 15, A.D. 1906, and complete the same on or before May 15, A.D. 1909, this act shall be void and of no effect, but the right of any person to recover damages by reason of anything theretofore done by said company shall in no wise be impaired."

Land Purchases. — A large item of expense in this as in most extensive railroad improvements in the center of large cities was the cost of ownerships and easements acquired in real estate. A number of buildings devoted to business purposes on North Main and Canal streets were purchased, also fine valuable residences on Benefit, Thomas, Congdon and Angell streets, near the west end of the tunnel, as well as a large number of smaller and less valuable dwellings near the east end of the tunnel. Purchase was made of a considerable area bordering on the westerly harbor line of the Seekonk River, which land was subject to tide range. All of this real estate is in the city of Providence.

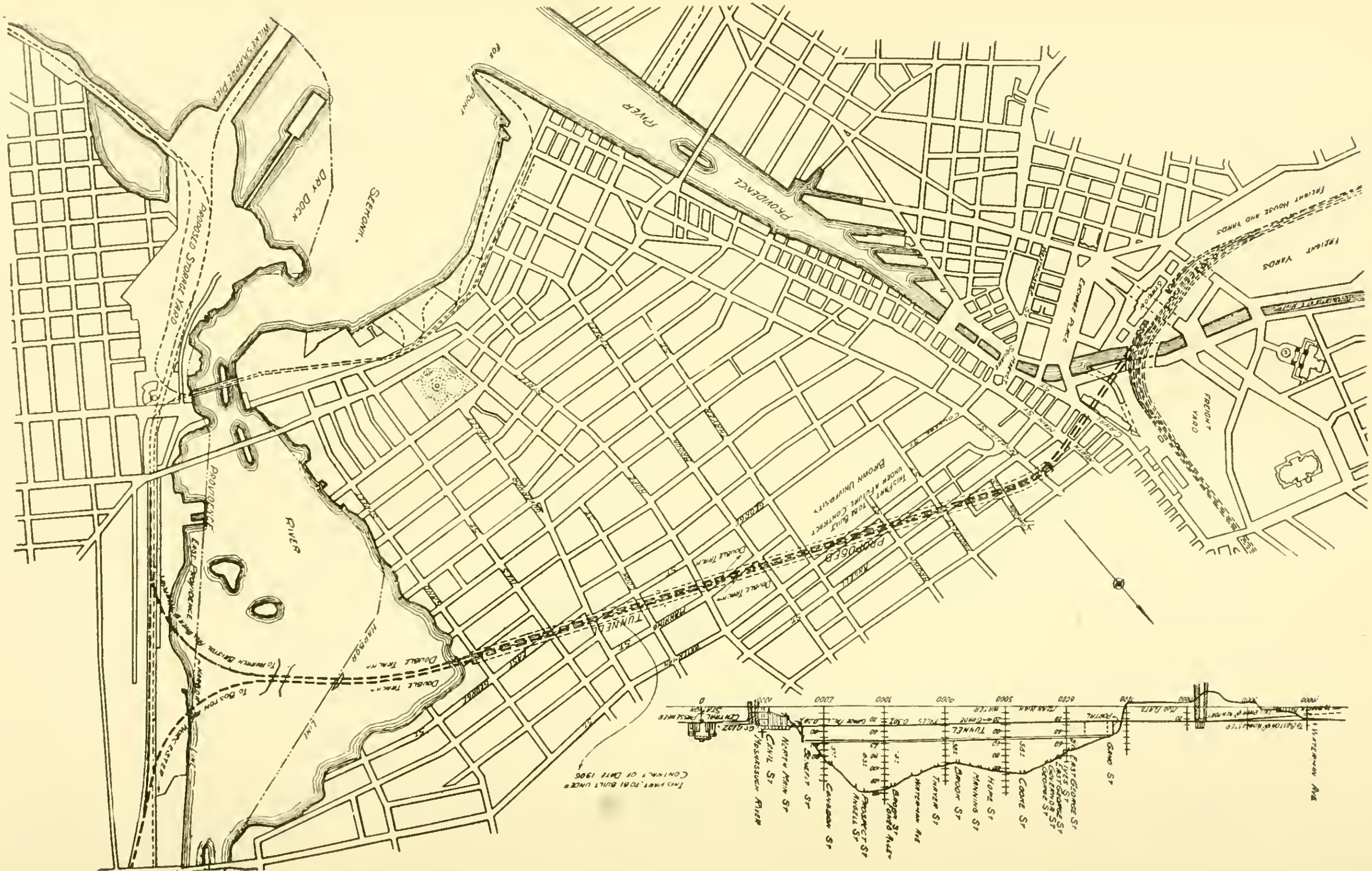
In East Providence considerable real estate was acquired north of Waterman Avenue and along Water Street quite a distance south of Waterman Avenue. This property was less expensive than that purchased in Providence.

Land Easements. — In addition to property acquired by purchase, an easement was taken by condemnation for the construction and maintenance of the tunnel under the surface, through the property on the tunnel line, between the westerly sides of Congdon and Gano streets. This easement gave the right to construct and maintain a tunnel within a width of 100 ft., with the vertical limits defined between the plane of mean high water "Providence base" for the lower limit, and distances varying from 46 to 61 ft. above mean high water for the upper limit. This upper limit varied from 5 to 85 ft. below the actual surface of the ground.

The exact language of the taking in this particular as filed in court may be of interest.

ABSTRACT FROM PROVISIONS OF LOCATION FILED IN COURT TO COVER "EASEMENT TAKING."

"The vertical limit of the right and easement taken in the lands between the westerly side of Congdon Street and the west side of Gano Street is defined as follows: The upper vertical limit



Providence Improvement. Plan and Profile of Tunnel.

is defined by a series of planes, which through the entire width of said right and easement are defined by a line which shall pass under the streets named below at a maximum elevation above mean high water, the city of Providence base of levels, not to exceed the following elevations:

At Congdon Street	61 ft.
At Prospect Street	61 ft.
At Brown Street	60 ft.
At Thayer Street	59 ft.
At Brook Street	59 ft.
At Hope Street	58 ft.
At Cooke Street	57 ft.
At Governor Street	56 ft.
At Ives Street	54 ft.
At Gano Street	46 ft.

"Between each two consecutive points named, the said upper planes shall not rise above a straight line joining the said two points, as delineated hereon and marked 'Diagram showing vertical limit for right and easement.' The lower vertical limit of said right and easement is a plane which coincides with mean high water, the city of Providence base of levels."

In other words, easement for the tunnel was taken under the various properties traversed by the line, which easement was a carefully defined volume of the earth definitely bounded on all four sides.

For several hundred feet from each portal to points where the minimum depth from the surface to top of tunnel was less than 30 ft., title in fee was acquired to avoid possible future complications that might arise from private ownerships.

The total cost of all real estate acquired in the city of Providence was the equivalent of one half of all construction costs of the work from the Union Station to the west harbor line of the Seekonk River.

Arsenal Property. — One of the most difficult, as well as interesting, real estate transactions was the acquisition of the arsenal property on the west side of Benefit Street, directly on the line of the tunnel. This had to be purchased and the old stone building moved to a new site.

It was found that the fee of the land and ownership of the building was in the state of Rhode Island, against which the right of condemnation of the property could probably not be maintained. It further developed that the greater part of the building was leased by the state to the Providence Marine Corps of Artillery, an organized military company, for a term of one

thousand years from June 23, 1852, and at a yearly rental of six and a quarter cents. As the state kept the building in repair, paid taxes — if any were assessed against the property — and was otherwise responsible as owner, it can readily be seen that the military company was much better off than it would have been if a new arsenal building were presented to it, with a deed of possession to both building and land. The outcome of the case was that valuable adjoining land, at the corner of Benefit and Meeting streets, was purchased by the railroad interest and deeded to the state of Rhode Island; the old stone arsenal building was moved to this new site, put in better condition than before, and the matter fixed up legally, so that the same relations exist between the state of Rhode Island and the military company. When this was accomplished the state deeded the old arsenal lot to the railroad.

Abstracts from the deed and lease of June 23, 1852, referred to, follow.

Abstract of Deed, Providence Marine Corps of Artillery to State of Rhode Island and Providence Plantations.

"Providence Marine Corps of Artillery in consideration of $600 . . . does hereby convey to the State of Rhode Island and Providence Plantations and its successors forever one certain lot of land with all the improvements thereon . . . June 23, 1852."

Abstract from Lease, State of Rhode Island and Providence Plantations to Providence Marine Corps of Artillery.

". . . State of Rhode Island and Providence Plantations for and in consideration of a certain conveyance of Real Estate made by said Providence Marine Corps of Artillery to said State of Rhode Island and Providence Plantations bearing even date herewith, does hereby demise and lease unto the said Providence Marine Corps of Artillery, their successors and assigns, the following described premises, to wit, — That portion of the State Arsenal, so called, situated in the City of Providence, which said Providence Marine Corps of Artillery now occupies, consisting of the Hall and entire room upon the street, to be held to the sole and exclusive use of said Providence Marine Corps of Artillery, their successors and assigns, the south tower of the said building to be held to the exclusive use of said Providence Marine Corps of Artillery, their successors and assigns, as a flag and storage room and for other purposes. . . . (Some space reserved for Quarter Master General). . . .

"The said Providence Marine Corps of Artillery, their successors and assigns, also having the privilege of using and occu-

pying the Basement of said Building for the purpose of keeping therein their cannon, caisson, harnesses and other equipments with right of entry thereto for the purpose of taking them out and returning them, and also for the purpose of reaching and taking care of their furnace situated in the northeast corner of said Basement and for such other purposes as may be allowed by the Quarter Master General for the time being. . . .

"To have and to hold the said Premises with their appurtenances to them, the said Providence Marine Corps of Artillery, their successors and assigns, for and during the time of one thousand years from and after the date hereof, they paying therefor to said State of Rhode Island and Providence Plantations and its successors the yearly rental of six and a quarter cents.

"Dated June 23, 1852."

Alignment.

General Route. — A description of the new tunnel line and its approaches is as follows:

Starting at the easterly or northeasterly end of the Union Station, the line passes over the Woonasquatucket River and Promenade Street bridges, then over the freight yard and freight house on the west side of Canal Street, crossing Canal Street and North Main Street, with a clear head room of 16 ft. and 14 ft. respectively, to the east side of North Main Street, the alignment of the tracks going easterly, being very nearly a prolongation of the tangent at the station for a distance of about 1 200 ft.; thence by an 8-degree curve to the right 600 ft., passing under Benefit Street and extending 360 ft. into the tunnel; thence easterly by a tangent 4 720 ft. to the east portal of the tunnel at the east side of Gano Street; this tangent extends 250 ft. beyond the east portal on an embankment about 22 ft. above high water, made with material excavated from the tunnel; easterly from this tangent there is a 2½ degree curve to the right for 560 ft., still on the embankment, to the tangent extending over new Seekonk River roller-lift drawbridge. This tangent is 800 ft. long to a point about 40 ft. east of the channel span, where there is a double track junction on the bridge structure over the river; from this double track junction the south leg of a Y turns to the right for about 90 degrees, with a 7-degree curve, and joins the old tracks in East Providence leading to the south to India Point, Wilkesbarre Pier coal wharf, Warren, Bristol, Fall River and Newport; the north leg of the Y turns to the left for about 70 degrees, with a 6½-degree curve, and about 200 ft. south of Waterman Avenue, East Providence, joins the tracks leading northerly to East Junction; thence to Attleboro, Mansfield and

Boston. Just at the north side of Waterman Avenue another double track junction is formed, with a new piece of double track line built across a pond to connect with the existing double track line from East Providence to Valley Falls, where it connects with the line from Providence to Worcester, and the line from Valley Falls to Franklin, Mass. This last line connects by two other routes to Boston.

Tunnel Route. — " The tunnel alignment is a tangent, except for a short distance at the west portal, where the axis of the tunnel is for about 350 ft. on an 8-degree curve. The grade descends at the rate of 0.25 per cent. for about 200 ft. from the western portal and then rises at a grade of 0.193 per cent. for about 1 150 ft., beyond which it falls at a grade of 0.291 per cent. to the eastern portal. The cross-section is a three-center basket-handle arch with plumb walls, having a width of 30 ft. and center height of about 24.5 ft. above subgrade and 20 ft. 6 in. above the top of outside rail.

" The tunnel passes diagonally under the streets of an area closely built up with handsome houses, so that the surface alignment encountered many obstructions and was made from a traverse line run wherever convenient, points and distances being established from which points on the axis of the tunnel were readily computed and platted. Angles were read with a Buff & Buff triangulation transit graduated to 10 sec. Linear dimensions were measured with a 100-ft. steel tape with the usual spring balance tension adjustment and thermometer for temperature corrections. All angles and measurements were repeated several times, and the latter were made on the surface of the ground direct from point to point without the use of plumb bobs, regardless of the slope, which was afterwards determined by running a line of levels and computing the horizontal length of the line from the known parts of the triangles, the traverse thus made showing an error of closure of 1-50 000.

" The profile of the surface of the ground rises sharply from El. 55 at Benefit Street to El. 140 at Prospect Street, in a distance of 1 000 ft., thence descends for 1 500 ft. to the Brook-street valley to El. 92, then rises for 1 100 ft. to a second summit at Cooke Street at El. 110, then falls to the portal at Gano Street at El. 47. This contour made it possible to locate two towers on the western slope, one on the Prospect-Street summit, one on the Cooke-Street summit, and one on the eastern slope, on the roofs of houses so arranged that the tangents could be tested and corrected. Angles and distances were calculated from the

traverse lines run on the cross streets, and points thrown on to the platforms; then from the computed angle at Gano Street the line was thrown to the tower between Ives and Governor streets and projected across the hill. This line struck $\frac{3}{4}$ in. north of the point on Benefit Street fixed for the other initial point, and this variation was not exceeded at any intermediate point.

"Two points on the surface of the ground were located in the axis of the tunnel at the west end, and 5-in. artesian well holes were drilled vertically in the rock, permitting plumb bobs to be suspended in the tunnel to determine points in the tangent. At the east end of the tunnel, points 0.5 mile apart were permanently located in the extension of the axis tangent across the river, so that the line could easily be produced from the open cut through the portal.

"As the tunnel was driven, line and level marks were made on the floor plugs temporarily established in the heading, because the rock in the roof was so soft and unreliable that they could not be placed there. As fast as the headings advanced beyond each 100 ft. regular station, a well 2 ft. deep was blasted there in the floor of the heading and filled with concrete in which was set an 8 in. by 8 in. vertical wooden post, on which the marks were maintained until the concrete roof arch was completed, and the marks were transferred to plugs drilled in it. Permanent marks were finally established in the tunnel floor after those in the heading were destroyed by the removal of the bench. These precautions were efficient, and the accuracy of the work was so great that when the headings finally met, both lines and levels from the opposite portal corresponded within half an inch."*

A peculiarity was noted in the action of alignment and level plugs set in the bottom of the heading, that may or may not correspond with observed action in other tunnels. It was noticed that many of the first alignment stakes that were set in a substantial batch of concrete deposited on the floor of the heading showed a movement of half an inch or more both sideways or vertical. The most reasonable theory seemed to be that when a portion of the original hill was removed by the excavation of the pilot heading, an opportunity and space was thus given for the surrounding material to expand and move toward the free space, and that this was more likely to occur in rock of miscellaneous character, with no defined stratification, than in a more solid rock with regular stratification. The movement

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* *Engineering Record*, November 7, 1908.

seemed to cease after the enlargement of pilot heading had been completed symmetrically on both sides.

West Approach Viaduct Construction.

Providence Viaduct. — The viaduct forming the west approach to the tunnel from the Union Station to the west portal is about 1 200 ft. long, and passes over Woonasquatucket River, Promenade Street, Moshassuck River, a part of the yard and one of the freight houses on Canal Street, Canal and North Main streets. For 660 ft. of its length it was built of steel girders with solid, watertight floors consisting of reinforced concrete, carrying the ballast and tracks. The viaduct carries from 4 to 7 tracks, with liberal platform space contiguous to the station end. There are about 4 000 tons of steel in this structure, forming about 72 000 sq. ft. of bridging, of which 54 000 sq. ft. has reinforced concrete floors.

Superstructure. — The viaduct superstructure consists of steel columns supported by concrete bases resting on piles cut off below water level. Above the columns are generally transverse girders, some of box type and some of simple girder type. In a number of places longitudinal girders carrying the floor rest directly on the columns. The reinforced concrete floor is directly carried for a considerable area by 24-in. rolled beams, spanning two freight tracks below, beams spaced 18 in. apart and resting on transverse box girders, and for other portions by deeper plate girders with necessary cross supports between these plate girders. These deeper plate girders are carried by transverse simple girders, or rest directly on columns. Where headroom was most important, under the viaduct, the thickness of metal floor and reinforced concrete was made 2 ft. 3 in., and the total thickness from base of rail to underside of viaduct, not counting the transverse girders, was made 3 ft. 9 in. Where the viaduct crosses the freight yard, provision was made for spanning ten tracks. The extension of this bridging passes through freight house No. 1, fronting on Canal Street, the floor of which was obstructed only by six steel columns; and good working headroom in the house is still left under the solid floor of the viaduct. At Canal Street the distance from base of rail to underside of girders crossing the street was made 7 ft. 4 in., which gave clear headroom of 16 ft. for Canal Street.

Woonasquatucket River and Promenade Street Bridging. — To meet the grade conditions of the new tunnel line, a portion of the bridging carrying the former tracks over these structures was

Viaduct Eastward from Union Station.

West Portal looking West toward Union Station.

West Portal, Providence Tunnel (Unfinished).

Providence Viaduct at East End of Union Station.

raised by amounts varying from less than an inch to nearly 2 ft. This involved raising 18 trusses, each 106 ft. long, over the river, and 16 lines of box girders over Promenade Street, all carrying tracks laid on ballasted floor, with frequent passenger trains passing over them.

The structure built in the earlier work on the passenger station was well adapted for such raising, being practically separated at each 10 ft. in width into separate bridges, though so attached as to give ample side support to each other. The actual raising operations were so timed as to avoid lifting any locomotives or trains, although ample power was provided for such an emergency, and thin flat bars were inserted under each bearing as raised to avoid the risk of a drop should any one of the jacks fail. Sections of the bridge were raised a little at a time. It was found necessary to apply a lifting power sometimes as great as 600 tons under a section not over 20 ft. wide, this being for one end of a bridge about 106 ft. long.

The total area of bridging thus raised was about 34 000 sq. ft. About two thirds of this area was planked with 6-in. hard pine flooring laid continuously over both the trusses that were raised and those that were not. This heavy flooring therefore had to assume a warped shape to correspond to the new conditions.

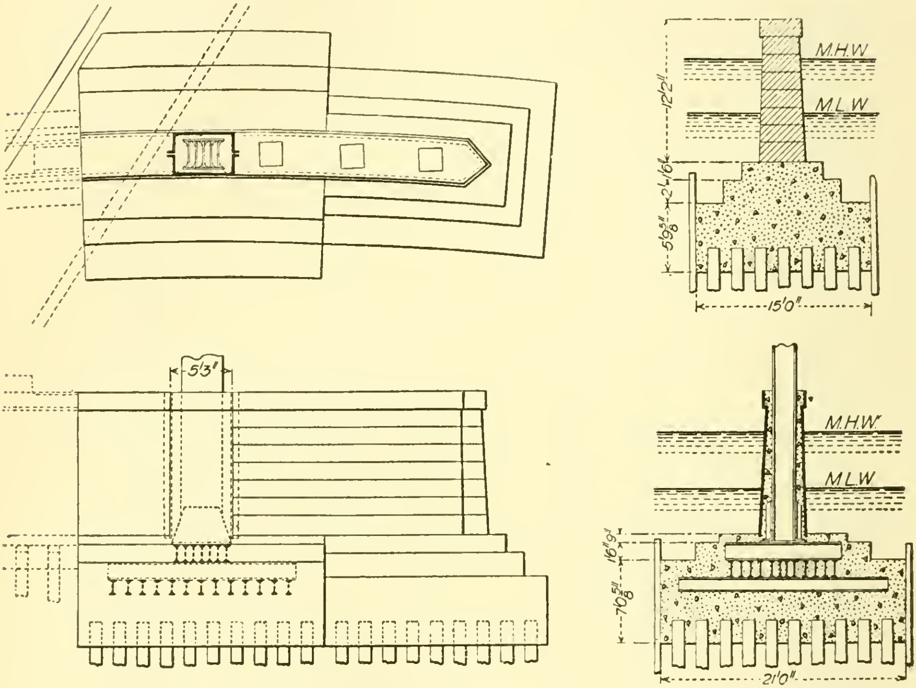
A notable thing about this timber flooring is the uniformly excellent condition in which it was found. It was originally laid down in 1895, a good quality of hard pine timber not treated with any preservative process being used. Over it was laid several thicknesses of tar paper mopped together as for a gravel roof. At a number of places openings were made, perhaps 2 in. in diameter, to let the water from the ballast floor drip through into the river below. In 1908 this timber flooring was examined at a number of places by digging down to it, and it was without exception found wet and in as bright condition as when laid. Only at the extreme edges of the large area covered, where the timber could dry out and then become wet again, was there any rotten wood. It did not seem to be affected in this way for more than 2 or 3 ft. in from the exposed edge of the work.

The work of raising this bridging was successfully completed, without mishap, and was carried out by the S. W. Bowles Company, of New York.

Moshassuck River Pier. — Where the viaduct crosses the Moshassuck River, at a height of about 28 ft. above high water level, it became necessary to partially support the structure

on an existing pier in the center of the river, which had a concrete footing and pile foundation about 7 ft. below low water level, designed to support only a light highway bridge.

"The bearing area of this footing was not sufficient to sustain the 1 000 tons of additional load, and as the channel is already



Moshassuck River Bridge Pier.

very narrow, it was inadmissible to obstruct it by a wide pier or by footings encroaching on the existing waterways. It was, therefore, determined to carry the steel column down to the foot of the pier shaft and there support it on a steel I-beam grillage, which occupies a comparatively small vertical height and distributes the load over a pile foundation about 20 ft. square at a level low enough not to interfere with the present waterway. The structure was accordingly designed as shown by the accompanying drawings; a sheet pile cofferdam was built around the end of the existing pier, a portion of the old masonry removed, the enclosure excavated to the required depth with an orange-peel bucket, and additional piles driven as required for the new foundation. The pile tops were cut off 16 ft. below high water

level and enclosed in a mass of concrete deposited to a thickness of 3.5 ft. by bottom-dump buckets under water. After the concrete had set so as to seal the bottom of the coffer-dam, the latter was pumped out dry and the grillage beams set and concreted, the steel column placed and enclosed in a cast-iron shell of the same cross-section as the pier, the space between the column and the shell concreted solid, and the pier masonry built up against the iron jacket, completing the work and giving it the final appearance of an ordinary steel column supported on the top of the pier, when in reality the column passes through the pier and is supported on a practically independent footing below it."*

Quantities. — The construction of this viaduct required the following quantities of work and materials: 11 000 cu. yd. of excavation, 157 000 lin. ft. of foundation piles, 8 000 cu. yd. granite masonry, 5 700 cu. yd. Portland concrete masonry, 190 cu. yd. reinforced Portland concrete masonry, 7 800 000 lb. of structural steel, 91 000 lb. corrugated steel rods, 22 000 sq. ft. of Clinton wire cloth.

Tunnel Construction.

Character of Material. — The preliminary indications were that the greater part of the excavation would be in solid rock, which it was hoped would prove sufficiently strong and sound to enable the tunnel to be constructed without timbering. It afterward developed that, although rock existed throughout the alignment, the stratification was very irregular and variable, which, with the peculiar quality and other conditions encountered, made the excavation difficult and dangerous and necessitated very careful timbering, heavy permanent lining, and the use of special methods of construction and precautions not originally anticipated.

The rock was chiefly a species of soft shale in strata from a small fraction of an inch to several feet thick, with thin seams of graphite material between them. Several geological faults were found in the vicinity of the tunnel, and the rock was folded and distorted into all shapes. In some cases a complete "S" was formed in 20 ft., bringing the strata alternately into horizontal and vertical planes and through all intermediate angles. The rock was found to be very treacherous and unreliable, and even when comparatively sound after excavation soon deteriorated, so that large masses might be pushed in by lateral pressure over the inclined seams lubricated by the graphite; or masses in the

* *Engineering Record*, December 12, 1908.

roof, which appeared to be solid, after a few days became loosened and fell if not supported. It was, therefore, necessary to provide heavy timbering as fast as the excavation was made and to replace it everywhere with a heavy concrete roof.

A good idea of the nature of the materials encountered was shown by the progress profile on which some of the descriptions marked from the east to the west portals were as follows: Very fine sand saturated with water; glacial till; grit and fine seamy conglomerate; fine grit and hard shale with some graphite, laminated; carboniferous shale, principally graphite; fine sandstone; increasing quantity of graphite; carboniferous shale, principally graphite near roof, wet and very heavy; talc, schist, rotten slate and quartz, very heavy; carboniferous shale and sandy schist, with some talc and considerable graphite, wet and heavy; water veins, slate, hard and comparatively dry; hard-pan and rotten stone; shale, talc and schist; veins of graphite in considerable quantities in fine sandy dry shale, liable to slip and requiring continuous timbering; sandstone; graphite, with large veins of quartz; fine sandstone, with thin seams of graphite; water-bearing carboniferous shale, with veins of graphite, laminated.

Excavation. — The tunnel was constructed entirely from the portals without the use of shafts, and excavation was commenced at both ends, with center top headings about 10 ft. wide and 10 ft. high. All of the material encountered, even including the hard-pan, was drilled by two pneumatic drills mounted on columns in each heading and blasted with 40 per cent. dynamite. The work was done with two 10-hr. shifts of about 18 men each. As usual, each shift concluded its work by firing the holes drilled and charged by it, and an interval of an hour was allowed to elapse for the fumes to be dissipated before the next shift commenced work mucking the displaced material, after which they drilled and blasted, making an average advance of about 160 ft. and a maximum of 217 ft. per heading per month. The muck was loaded into wooden 1-yd. end dump carts and run on 24-in. gage tracks, which were suspended from the roof for a distance of about 30 ft. beyond the face of the bench, to enable the material to be delivered directly to the steam shovel, which loaded it in the larger cars by which it was taken out of the tunnel.

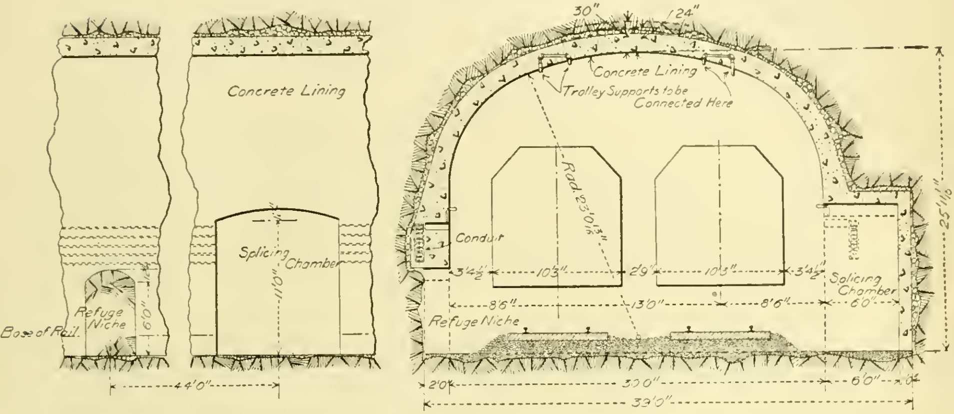
The headings were enlarged for the full width of the tunnel, the excavation being made in two successive sections, leaving a bench nearly 18 ft. high in the center above the floor of the tunnel, which was not removed until after the permanent concrete roof

View of Bench.

Finished Excavation.

TUNNEL HEADING.

had been built, releasing part of the timbering, providing an unobstructed working space, and affording complete safety for the workmen. At each side of the tunnel the rock was excavated about 2 ft. lower than in the center, carrying it down to a point only 3 ft. above the theoretical spring line of the arch, where the curve of the intrados was so small that the overhang beyond the side walls was negligible. Here the roof excavation was



Standard Dimensions of Tunnel.

widened, as indicated in the diagram, considerably beyond the original neat line for the arch, and an inclined skew-back surface was provided outside of the back of the side wall to afford support for the arch roof independent of the latter.

The removal of the bench followed the construction of the concrete roof arch at a distance of about 200 to 600 ft. As the clearance from the roof to the heading floor level was only about 7 ft., and the bench was 18 ft. high, the holes could not be drilled from top to bottom, and preliminary pits about 8 ft. deep were made 12 to 18 ft. apart transversely and 8 to 12 ft. back from the face of the bench. For these parts the holes were drilled inclined to nearly meet at the bottom, and when fired, blasted out a wedge-shaped portion of the rock, making a pit wide enough at the bottom for the drilling machine to be set up there and make two vertical holes about 4 ft. apart transversely and 10 ft. deep and 8 to 12 ft. back from the face of the bench. These holes were sprung twice with light charges to get the main charge down to bottom, and when the chamber thus formed had been blown out and loaded, it shattered about a 10 by 18 by 30 ft. prism of rock, which was generally reduced to pieces small enough

to be handled by the steam shovel without further breaking.

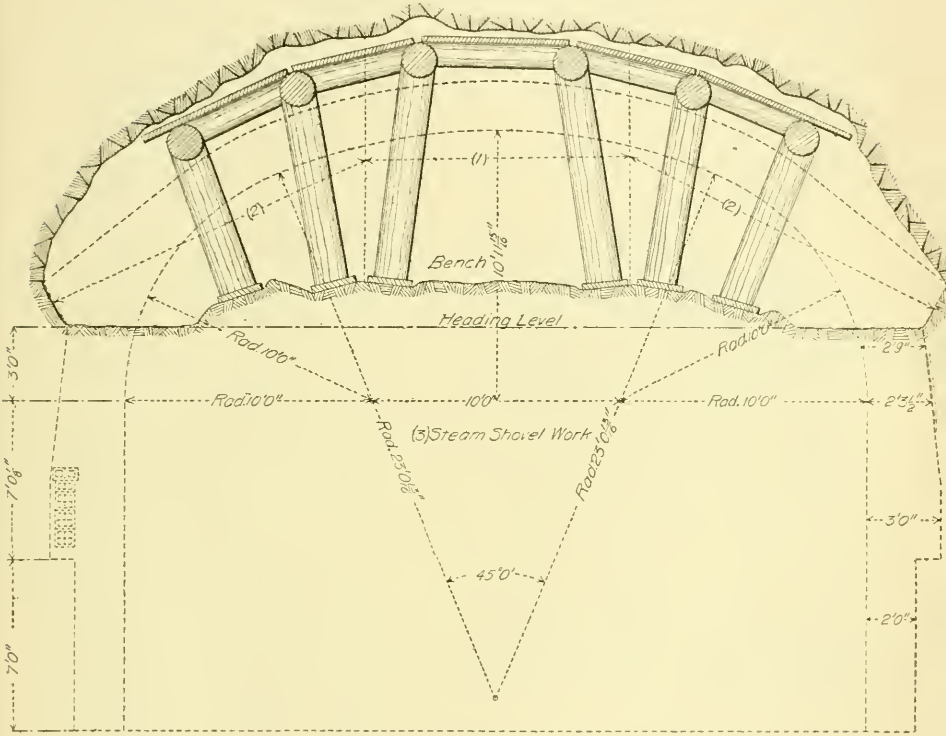
Two shifts of 6 to 10 men each, with four drills, were kept constantly busy making the pits up to a distance of about 100 ft. beyond the face of the bench, and were followed by 4 to 6 men with two drills, working double shift, drilling the lower tier of holes and blasting off the bench. In this way each bench was taken out at an average speed of 250 lin. ft. per month, sometimes reaching a maximum of 270 ft., and all the excavation was accomplished with an average of a little less than 1 lb. of dynamite per cubic yard of muck measured in the cut. The broken rock was handled by a Marion steam shovel operated by compressed air and having a 1-yd. bucket, which delivered to 3-yd. end-and-side-dump wooden cars hauled by an electric locomotive on a 36-in. gage track. The cars were usually run in trains of four, and at both portals were delivered to a steam locomotive, which hauled them out to the dump and returned them empty to the electric motor.

Disposal of Spoil. — In order to provide for the filled approach to the Seekonk River bridge, it was specified that about two thirds of the tunnel excavation should be made from the east end. Accordingly operations were commenced there in May, 1906. A Marion steam shovel working in open cut delivered the spoil to cars, which dumped it directly as required for the embankment. Rock was encountered in December, the open cut was finished in March, 1907, and the heading started from the east portal in April, 1907. The headings met April 6, 1908, at a point nearly midway between the portals. A large portion of the tunnel excavation was used for making fills, embankments and other railroad improvements.

At the west end the locomotive took the cars about 1 000 ft. beyond the portal to the crossing of the Moshassuck River, where the dump track was carried on a trestle about 30 ft. above water level. In the trestle was constructed a steel-lined wooden bin, about 50 ft. long, 20 ft. wide on top, and 20 ft. deep, provided with six horizontal steel gates on each side of the bottom, through which the muck was delivered at convenience to 30-yd. scows and towed 1.5 miles to make a 90 000-yd. fill at the Wilkesbarre Pier, East Providence.

Timbering. — The character of the material encountered and the nature of the stratification necessitated temporary timbering for the greater part of the tunnel. At one place in the heading, just easterly of Brook Street, the rock was altogether lacking for about 180 ft.

As fast as the heading was extended the roof was supported by round oak crown bars, and the timbering was advanced as close as possible to the drillers. The two No. 1 crown bars, located 3 ft. on each side of the center line of tunnel, were set in final position and supported on slightly inclined posts, and

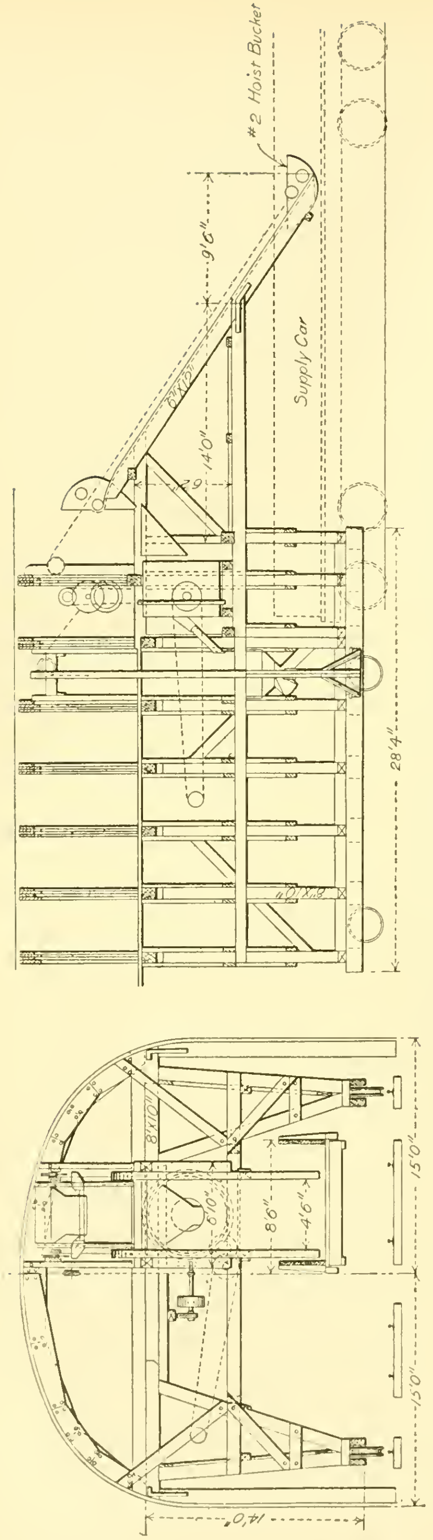


Roof Timbering Scheme.

sheeting planks were placed on them and the space above filled or wedged tightly against the rock.

In the hard-pan section near the middle of the tunnel, and at other points where the roof was not sufficiently self-supporting to allow even the narrow first heading to be driven without timbering, cross caps were set just above the grade of the No. 1 crown bars and supported on temporary posts, which were removed after a sufficient length of heading had been cleared to allow a 20-ft. crown bar to be placed under these caps and properly posted.

In the worst sections it was necessary to lag the roof tightly by driving poling boards ahead of the face of the excavation and



Jumbo Traveler for Mixing Concrete for Tunnel Lining.

follow the excavation immediately with lagging on the sides. In no case was it found necessary to keep the face of the heading lagged.

Two 10-hr. shifts of about 40 men each followed the heading gang with four drills and widened out the heading to the full width on both sides, at a distance of about 100 ft. in the rear. Timbermen set the remaining two pairs of crown bars, posts and roof boards, which completed the timbering and provided clearance underneath for the concrete arch.

Concrete Mixing Plant. — The tunnel was lined throughout with concrete generally made 1 : 3 : 5 with Alpha and Giant brands Portland cement and screened gravel, mixed in Ransom machines. These mixers were first located outside of the tunnel portals and delivered the concrete to 0.5 yd. 24-in. gage steel side-dump cars, from which it was dumped on each side of the track under the centering. After the work had advanced about 1 000 ft. from each por-

tal, four traveling wooden towers, called "jumbos," were installed in each end of the tunnel, and each rear jumbo was equipped with a concrete plant, moving forward as the work progressed. Sand and gravel were brought in by the large cars which took out the muck, and were delivered to an elevator, which discharged them into the elevated measuring hopper serving the concrete machine.

As the concrete mixing and the roof arch building were carried on simultaneously on opposite sides of the bench where the steam shovel was at work, it would have been very difficult to transport concrete by any ordinary system of surface tracks. Great convenience and economy were effected by the method devised under which the concrete cars were suspended from a trolley hanger running on the lower flanges of an I-beam, which was hung by the top flange to the roof like the muck track beyond the bench, by connections permanently built into the concrete arch to provide for the future installation of electric trolley wires.

Arch Roof Construction. — The concrete arch roof was built before the bench was excavated. As soon as possible after the heading was widened to the full width, arch centers were set up 4 ft. apart on centers, covered with a 3-in. by 4-in. planed lagging, and the roof arch was built, usually in sections 8 ft. long.

The centers were made of four thicknesses of ordinary 2-in. by 12-in. chestnut plank, framed to neat joints, bolted together and spliced at the centers with interlocking jaw pieces thoroughly bolted. They were accurately wedged to position and supported by posts like those used for the crown bars, but were not connected at the bottom by horizontal transverse ties. The lagging strips, 4 ft. long, were dressed to accurate radial joints, and those at the ends of the arch only were nailed to the centers. The lagging was placed for a height of 3 ft. above the skewbacks at each side of the arch; concrete was shoveled up to the upper edge and rammed in to fill all of the space back to the rock surface; a few additional strips of lagging were placed; more concrete rammed in, and so on, with men working simultaneously on both sides of the arch until the concreting was completed nearly up to the crown, where the remainder was placed on transverse keying pieces and rammed longitudinally. Twenty sets of centering were provided at each end of the tunnel and were allowed to remain in position at least six days, after which they were taken down in the rear and set up again in

front, the work being kept from 100 to 200 ft. behind the gangs that widened the headings.

The concrete in the arch roof averaged about $3\frac{1}{3}$ cu. yd. per linear foot of tunnel and was built at a rate of about 200 ft. per month at each end of the tunnel by a gang of about 30 men working one shift.

The preliminary designs provided for a uniform thickness of 18 in. for the arched roof, but the rock was found to be so much worse than was anticipated, that this thickness was increased to a minimum of 24 in., extending in some places to 30 in. In order to provide temporary skew-back supports during the time when the rock was removed under the bearings of the arch, preparatory to constructing the side walls, the radial thickness of the arch ring was increased to about 4 ft. at the spring line, and the walls were built with a minimum thickness of 2 ft., which, of course, was considerably exceeded on account of the irregularities of the rock surface.

The roof consisted of a three-centered arch with intrados radii of 10 ft. and 23 ft. and a thickness generally varying from 24 in. at the crown to 4 ft. at the skew-backs. Under Gano Street and Benefit Street the arch ring was reinforced 2 in. from the inner and outer surface with both longitudinal and transverse rods, and the intrados line was changed.

Side Wall Construction. — The construction of the side walls followed the excavation of the bench at a distance of about 100 to 500 ft., and, except the curved portions, was commenced in October, 1907, near the west portal and in January, 1907, at the east portal, and finished in August, 1908.

In the rear of each bench there were installed four wooden traveling towers or jumbos 30 ft. long, built of heavily braced connecting bents 4 ft. on centers of nearly the full height and width of the tunnel, which provided working platforms above the spring line from which the wall concrete was shoveled into molds formed by lagging attached to the sides of the travelers.

The travelers were wedged up under the roof arch to help support it while a section from 12 to 16 ft. long was undermined and strongly braced to make them rigid and provide clearance underneath the working platform for two tracks, on which concrete materials were delivered and muck was taken out from the steam shovel. Ordinarily, four of the travelers or jumbos were located at the forward end of the wall to carry the side forms, and the fourth "jumbo," with the concrete plant and elevating machinery already described, was maintained several hundred

East Portal, Providence Tunnel (Finished).

New Railroad Location Approach to Tunnel, East Providence.

feet in the rear and delivered the concrete cars to the overhead suspended tracks, on which they were run to the forward jumbos, where their contents were dumped on the working platforms and then shoveled into the molds and rammed in place.

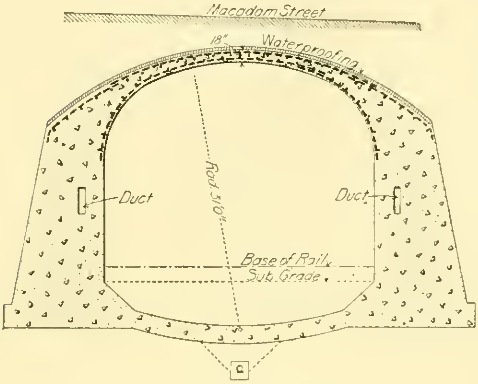
The rock was not excavated for the side walls until the last moment before the latter were built, when it was taken out in alternate sections, 10 to 18 ft. long, staggered on opposite sides of the jumbos, and separated far enough to avoid leaving more than 20 ft. of arch roof supported by the natural rock or new wall at one time. When the wall opposite each side of the forward jumbo had been completed, the jumbo was moved three panels or 90 ft. ahead, and the rock excavation and wall construction commenced there. As fast as the walls opposite the second and third jumbos were completed they were similarly moved forward and the work thus kept in constant progress at the rate of 150 to 200 lin. ft. per month. The forms were left in place at least three days after the concrete was laid, and the jumbos, mounted on double-flange wheels running on a single rail at each side of the tunnel, were easily moved forward by the electric locomotive.

In the hard-pan section it was found necessary to support the arch on posts on a timber floor which practically covered the heading level to within 3 ft. of the neat line of wall. The walls were then undermined by sinking pits to the rock, which had previously been located by borings and found to be in no case below sub-grade. These pits were opened about 10 ft. long, and as soon as the forms could be set up the walls were concreted. Care was, of course, taken to keep these pits well scattered to prevent overloading the hard-pan, for while they were open the total weight of arch and earth cover of from 40 to 50 ft. had to be carried on the central core and the adjacent soil, which was already very heavily loaded, the arch acting as a bridge to span the opening. By taking small sections well separated the plan was entirely successful.

The side walls at Gano Street resisted a very heavy lateral thrust from the backfill and had vertical inner faces and battered rear surfaces, increasing the thickness from 7 ft. at the top, being the thickness of the spring of the reinforced arch, to 12 ft. at the bottom, where they were made integral with the footings, and the latter were made continuous with the thickened invert.

In each side wall there were sixteen glazed tile conduits for electric wires made accessible through 10 by 12 ft. splicing chambers, about 350 ft. apart. Refuge niches 4 ft. wide and 7 ft. high were built in the side walls 44 ft. apart under the conduits.

Work at East Portal. — About 460 ft. of the east end of the tunnel was constructed by "open cut and cover work." A bed of quicksand 15 ft. deep was encountered at Gano Street and extended about 8 ft. below sub-grade. At first this caused some difficulty, which was obviated by digging a trench 6 ft. deep on the center line, in which was laid an 8-in. drain of open-joint vitrified pipe, with lateral branches 6 in. in diameter, reaching to the side wall footings and draining them thoroughly in advance of the concrete construction, which had a footing of coarse sand filled in to a depth of 1 ft. above the side drain, a construction which was entirely successful and prevented any settlement.



SECTION UNDER STREET.

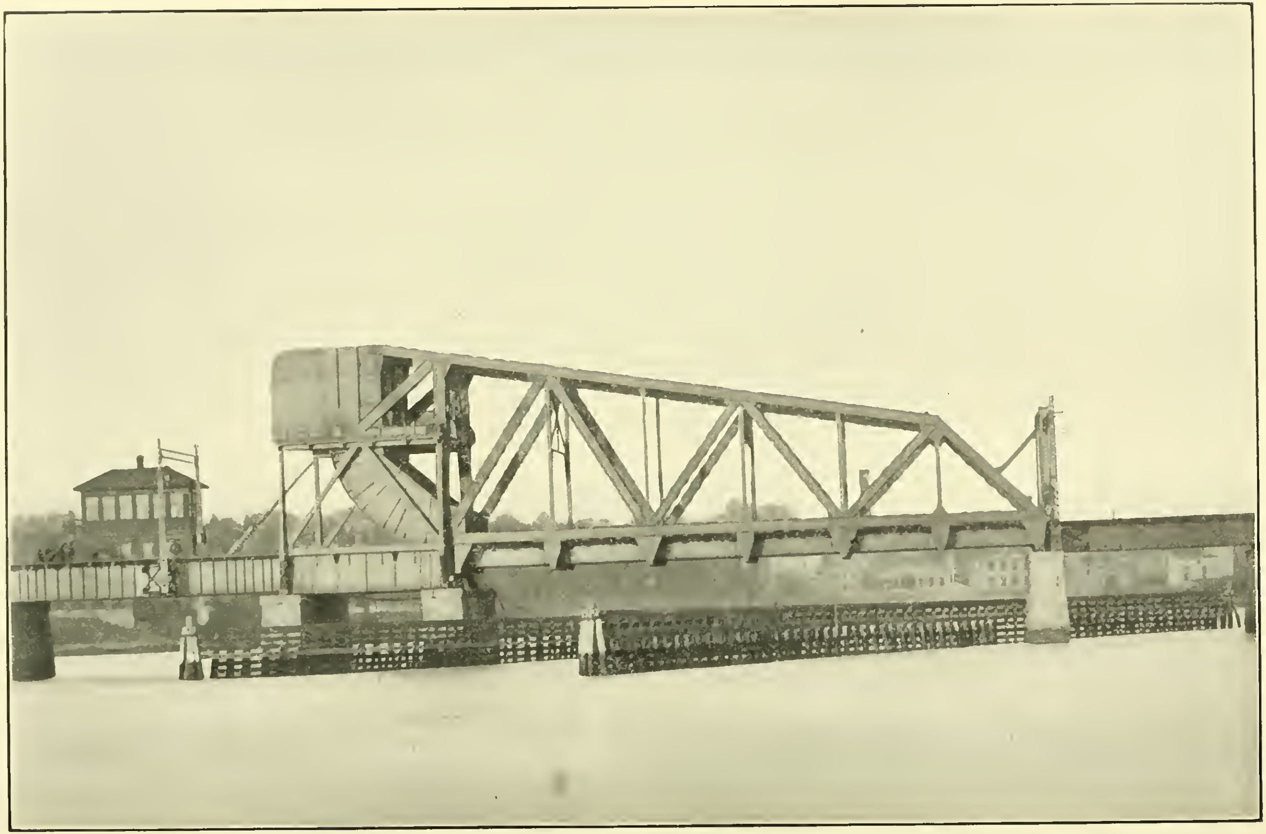
The presence of this quicksand necessitated the construction of about 70 ft. of segmental invert 24 in. thick to provide for distribution of load and possible upward reaction. The backfill under Gano Street had a minimum depth of 4 ft.

Contractor's Plant. — The work was executed with a duplicate plant installed at the east and at the west end of the tunnel. The principal items of one of these installations included 1 Marion steam shovel, 2 horizontal 100 h. p. return tube boilers, 1 Rand air compressor, with receiver and pipe line; 15 Sullivan drills; 4 half yard dump cars; 15 narrow gage flat cars; 2 General Electric locomotives; 1 steam locomotive; 2 Ransome concrete mixers; 4 jumbo travelers, manufactured by the contractors; 1 electric windlass elevator used on the concrete machine; about 3 000 ft. of 24-in. gage track for the overhead concrete cars and for the muck cars in the headings; and about 4 000 ft. of narrow gage track on the tunnel floor level, with numerous turnouts and sidings.

Progress. — The item of progress per day and per month is always interesting on work of this character, and frequently of considerable importance financially to both the contractor and promoter of the project.

There were 4 430 lin. ft. of tunnel driven, the remaining por-

Reinforced Concrete Bridge over Railroad at Waterman Avenue, East Providence.



Seekonk River Bridge, East Approach, Providence Tunnel.

tion, some at each end, being constructed by "open cut and cover work." The best six months' progress from the east end, from November, 1907, to April, 1908, was equal to 974 ft. of completed tunnel; this for 182 calendar days equals about 5.4 lin. ft. per day, and for 154 working days equals about 6.3 lin. ft. per day. The progress from the west end for the same period was equal to 1 230 lin. ft. of completed tunnel, being respectively 6.8 lin. ft. per calendar day and 8 ft. per full working day. The average total progress from both ends similarly reckoned was 14.3 and 12.1 lin. ft. The total progress from both ends for the 4 430 lin. ft. averaged 7.3 lin. ft. per calendar day and 8.4 lin. ft. per full working day.

Overhead Contact. — The tunnel line is electrically operated by direct current, transmitted by overhead contact at 650 volts, the No. 0000 trolley wire being suspended over the center of each track from pipe hangers built into the concrete arch roof.

Lighting. — The tunnel is lighted by electricity, 16 c. p. incandescent lamps being installed at intervals of 44 ft. The light brackets were connected to the conduit lines and projected from the inner face of the walls at a uniform height of 11 ft. above base of rail.

Track Work. — Tracks were laid 13 ft. center to center, New Haven road standard 100-lb. rail being used, laid on 8 ft. ties carried on rock ballast. This track work was done by the railroad under direction of J. M. Torr, division road master.

Seekonk River Bridge.

The bridge over Seekonk River carries a double track spaced 13 ft. center to center. It is a deck structure, with the exception of the Scherzer rolling lift bridge. The rolling lift span is 135 ft. center to center of piers, and as it crosses the channel on a skew gives a clear width between pile fenders of 90 ft. West of the channel span the tracks are supported by six deck plate girder spans, one of 37 ft., four of 74 ft., and one about 50 ft. East of the channel span there are five deck plate girder spans, one of 50 ft. and four about 60 ft. each. East of these spans the north and south legs of a Y are continued on two double track pile trestles, each about 450 ft. long, to the East Providence shore. The entire width of the river from the west harbor line to the east harbor line, measured on the center line of the bridge, is 1 150 ft. That portion of the bridge consisting of steel superstructure on granite piers is 800 ft. long.

Substructure. — The west abutment and the two westerly piers rest on piles cut off about 5 ft. below low water. Around the heads of the piles and for about 5 ft. thick on top of them Portland cement concrete was placed. The abutment and piers are of coursed granite masonry above the concrete, the backing being of Portland cement.

The remaining piers rest on piles driven and cut off to desired grade under water, and were built in open caissons, with bottoms 40 in. thick, consisting of four courses of timber. At six of these piers the piles were cut off 32 ft. below high water, requiring open caissons with sides about 32 ft. high.

Quantities. — The following quantities of work and materials were required on this bridge:

117 000 cu. yd. of dredging.
10 000 cu. yd. gravel fill.
20 500 cu. yd. riprap.
76 500 lin. ft. foundation piles.
14 200 lin. ft. fender piles.
66 700 lin. ft. piles in trestle.
417 000 ft. B. M. timber grillage.
462 000 ft. B. M. timber in trestle, etc.
232 800 lb. iron and steel in trestle, etc.
5 300 cu. yd. granite masonry.
2 300 cu. yd. concrete in core and backing.
340 cu. yd. concrete in counterweight of roller lift bridge.
3 473 000 lb. steel bridging.

East Approach Construction in East Providence.

A new double-track railroad, about one half a mile long, was constructed in East Providence, a part of the location being in a cut through a sand hill, but the greater portion was on a 20-ft. fill through a pond north of Waterman Avenue. This new piece of track lies between the two former railroad lines from East Providence, one extending toward Valley Falls and Worcester, and the other to East Junction, Attleboro, Mansfield and Boston. About 100 000 cu. yd. of grading was required on this work.

Waterman Avenue Bridge. — This relocation of a portion of the lines at this point necessitated the construction of a new bridge to carry Waterman Avenue over the tracks. The bridge was built of reinforced Portland cement concrete, and varied in width from 53 ft. 6 in. to 61 ft. There were ten reinforced concrete girders 2 ft. 5 in. deep, between which and running transversely thereto the floor slabs were built 6 in. thick and reinforced with round steel bars, spaced 6 in. apart. The entire thickness of the roadway floor was 2 ft. 10 in., and the depth from the

top of the sidewalk curbing to the under side of the bridge was 3 ft. 3 in.

An ornamental fence or balustrade of reinforced concrete 42 ft. long was built on each side of the roadway. The bridge carries two street railway tracks.

The cost of this structure, under contract prices, was about $2.30 per sq. ft.

Interlocking.

The interlocking and signal work required on the whole line was very extensive. In a length of 2.5 miles of roadbed there were installed two mechanical interlocking plants, with a total of 74 working levers, and a proportion of spare space, and two all-electrical interlocking plants, with a total of over 80 working levers.

One of the all-electrical plants was placed in the operators' house on the Seekonk River bridge at the west end of the draw span, and moved junction switches at the east end of draw and derail switches on shore at both ends of the bridge.

The other all-electrical plant was installed in a three-story concrete tower built at Promenade Street near the beginning of the new tunnel line at the Union Station, and had a capacity of 70 working levers.

All the interlocking plants referred to control 140 switches and movable point frogs and about 100 semaphore signals.

The material was furnished by the Union Switch and Signal Company, and installed under the direction of C. H. Morrison, signal engineer of the New Haven road.

General Data.

Franchise act passed April 13, 1904.

Work commenced April 19, 1906.

New double track line went into operation November 15, 1908.

Length of new double track line, 2.7 miles.

Tons of steel bridging, 6 000.

Area new bridge flooring, 2.75 acres.

Total length as single track of new bridging, 10 200 ft., or the equivalent of nearly one mile double track elevated railroad.

Span, center to center channel piers Seekonk River bridge roller-lift draw, 135 ft.

Moving weight roller lift draw, 1 550 tons.

Number piles on new line, 9 500.

Masonry on entire line, 70 000 cu. yd. (of this 43 000 cu. yd. of concrete is in the tunnel and portals).

Length of tunnel, portal to portal, 5 080 ft.

Cubic yards of excavation in tunnel, nearly 200 000.

Height of tunnel, 22 ft. 3 in. over top of rail.

Width of tunnel, 30 ft. for double track.

Greatest depth, surface to top of tunnel, 90 ft.

Variation of alignment when headings met, $\frac{3}{8}$ in.

Headings met April 6, 1908.

Tunnel bore completed to sub-grade, September, 1908.

Engineers.

The original tunnel layout was schemed by the writer prior to 1898, and the details later worked out and carried forward to successful completion under his immediate direction.

The project was presented by the writer in 1904 to Mr. F. S. Curtis, M. Am. Soc. C. E., then vice-president of the New York, New Haven & Hartford Railroad, and by him examined critically and endorsed.

Herbert L. Ripley, M. Am. Soc. C. E., was resident engineer during construction.

H. R. Wescott, assistant engineer.

The work was executed under the general supervision of the engineering department of the New Haven road: E. H. McHenry, M. Am. Soc. C. E., vice-president; Edward Gagel, M. Am. Soc. C. E., chief engineer; William H. Moore, M. Am. Soc. C. E., engineer bridges.

Contractors.

The following were contractors on the more important parts of the work:

McCabe & Bihler Company, tunnel construction.

Holbrook, Cabot & Rollins, substructures Seekonk River bridge.

C. W. Blakeslee & Sons, substructures Providence viaduct; also reinforced concrete floors for bridges in Providence and East Providence.

S. W. Bowles & Co., erectors of steel work Providence viaduct, and the overhead bridges, supporting signals and electrical work.

Phœnix Bridge Company, superstructures for Seekonk River bridge, including Scherzer rolling lift.

Eastern Steel Company, steel for a part of Providence viaduct.

L. F. Shoemaker & Co., steel for a part of Providence viaduct.

Providence Steel and Iron Company, steel work for overhead bridges supporting electrical work and signals.

O'Connor & Andrews, abutments and walls, Waterman Avenue bridge.

Union Switch and Signal Company, interlocking material and signals.

In conclusion the writer desires to acknowledge the courtesy of the *Engineering Record*, by whose permission reproduction of several cuts illustrating tunnel construction is made possible, and from whose excellent article frequent quotations have been made; also to the *Railway Age*, for permission to reproduce cut of "plan and profile of tunnel," and to J. R. Hess of the editorial staff, Providence *Journal*, and Frank W. Marshall, chief of Art Department of the Providence *Journal*, for many photographs.

[NOTE. — Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by August 15, 1909, for publication in a subsequent number of the JOURNAL.]

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NOTES ON CERTAIN POINTS IN THE DESIGN OF LARGE FILTRATION PLANTS.

By S. BENT RUSSELL, MEMBER OF THE ENGINEERS' CLUB OF ST. LOUIS.

[Read before the Club, April 7, 1909.]

DURING the past year the writer has had occasion to visit a number of important filtration plants. This paper is to present to the club the results of the visits and of studies in connection therewith. The paper will begin with a brief review of methods of filtration now generally adopted for city water supplies. A brief outline of the component parts of a modern filtration plant will follow. We will give especial attention to the appliances connected with the washing of the filters and close with notes on individual filter plants.

Methods of filtration may be conveniently divided into three groups:

I. Slow sand filtration where sand beds of large area are used. Fine grained sand is used, effective size 0.3 to 0.4 mm., say, less than $\frac{1}{64}$ in. Coagulants are not used in typical systems, but the impurities in the water are expected to be of such character that they will line the interstices of the top layer of sand, forming a blanket, which will strain out the solid matter that follows, allowing only the pure water to pass. At intervals the top layer is scraped off by hand labor. When the bed is reduced to the minimum thickness new or clean sand is added to give the maximum thickness again. The filter units are usually about one acre in extent, and the rate of filtration is about 2 000 000 gal.

per acre per day. Where the winters are cold, the beds are usually covered.

II. Mechanical filtration where beds of much smaller area are used. The sand used may be somewhat coarser than in slow sand filters. Chemical treatment of the water is given to make coagulating precipitates which rapidly form a blanket in the top layers of sand and strain out the solids from the water. One or more times each day the bed is washed by mechanical means, which always include an upward flow of water. In large plants the filter beds are each about a hundredth part of an acre and the rate of filtration is about 120 000 000 gal. per acre per day. We may note that the capacity of a single unit is not greatly different in this system from what it is with the slow sand method, while the rate per acre is many times greater.

III. Methods of filtration where large beds of sand are used, as in I, but where a higher rate of filtration is used. Special methods or appliances are used by which the sand surface is cleaned at intervals without being removed from the bed. This method of filtration is given place here as it is contemplated, it appears, for a very large filtration plant proposed about a year ago for the Croton Water Supply. A rate of 10 000 000 gal. per acre per twenty-four hours is expected. It is probable that the method will only be successful with waters carrying little sediment.

Besides the above three methods of purifying water we have other well-known processes, such as sedimentation with or without coagulants, aëration, ozone treatment, etc.

In comparing the methods of filtration named above, it may be said that for turbid waters in the United States mechanical filtration has been preferred in the majority of cases. Mechanical filters have a decided advantage where cold winters prohibit the open bed. The records indicate that, as usually operated, a higher degree of purification is obtained with the slow sand filter.

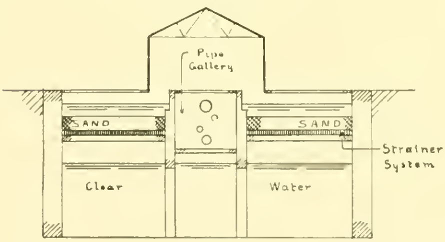

FIG. 1.— CROSS-SECTION OF TYPICAL MECHANICAL FILTER PLANT.

In choosing the general method to be adopted for a large filtration plant, the first thing to do is to determine the governing local factors. It is a pleasure to note that in a number of cases

in this country this has been done as it should be and preliminary plants of an experimental character have been installed. With experiments made in these plants, data were obtained from which to determine the most economical system of water purification. While information thus obtained is not always conclusive, it is certainly unwise to proceed without it, and its value must generally be greater than its cost. For similar reasons, wherever filtration is regarded as a future possibility, it is wise to adopt a system of accumulating data in regard to the water, such as varying composition and turbidity and reaction to treatment. Great savings are sure to be made by this practice, and engineers should encourage it.

There are five important parts in a typical filter plant:

First. The settling basins in which more or less of the impurities are removed before filtration.

Second. The coagulating plant for adding chemicals to the water which will form precipitates aiding both sedimentation and straining out of impurities.

Third. The sand beds or filters proper.

Fourth. Appliances for washing and agitating the sand, including piping and storage of wash water. In mechanical systems a compressed air plant may be added. In slow sand filters appliances for removing, washing and replacing the sand are required.

Fifth. Appliances for regulating the flow of water through the plant and for controlling all operations. This will include meters, etc.

In laying out a plant, when the general method of filtration is determined upon, the question of size of filter unit will come up among the first things to be considered. For slow sand filtration the maximum size of filter units has been pretty well established by long usage. In mechanical systems the size of the filter unit has gradually been increasing. In the top lines of Table II we see the capacity of units in plants built at different times. Experience at Cincinnati shows that a unit of 4 000 000 gal. per day can be successfully operated.

Now while large units are desirable for some reasons, there are difficulties that come with their use. A mechanical filter unit may be taken as a sand-washing machine. It is easily shown that the difficulties of efficient washing increase with the size of the bed. So we see that the matter of washing appliances is one of primary interest in the design of mechanical filter plants.

The writer had occasion to visit a number of important

plants last year, as already stated, and was specially interested in noting the results secured by washing appliances in practical operation.

Let us now consider the following matters which come under the head of washing appliances:

Capacity of wash water plant.
Storage for wash water.
Distribution of wash water.
Pressures and velocities.
Agitation.
Trough system for wash water.
Waste pipe system.

Taking these subjects up in some detail, we will begin with the first.

The capacity of the wash-water plant and the size of the unit are, of course, mutually dependent. The required capacity may be expressed in its relation to other factors by a few simple formulas. The capacity may be measured in three ways, viz.:

Q_d = The amount of wash water required in a day of twenty-four hours.

Q_m = The maximum amount required per minute.

Q_w = The amount required for one washing of one unit.

Let R = Rate of filtration = number of cubic inches filtered per square inch of filter bed per minute;

and r = Rate of washing = number of cubic inches of wash water required per square inch of filter bed per minute;

and c = Capacity of one filter unit in gallons per day of twenty-four hours.

Then
$$\frac{1440}{c} Q_m = \frac{r}{R}. \tag{1}$$
and
$$Q_m = \frac{r}{R} \times \frac{c}{1440}. \tag{2}$$

For a rate of 120 000 000 per day R is about 3. For washing as done at Cincinnati r is 24 (see Table II).

Taking these values, $\frac{r}{R} = 8$ and $Q_m = .00555c$.

For c = 1 000 000 gal., $Q_m = 5550$. (3)

Let p = Number of gallons of wash water required to 100 gal. filtered, with worst water;

and t = Length in hours of filtering and washing cycle, with worst water.

$$Q_w = \frac{pct}{2400}. \tag{4}$$

In a given case, if $p = 3$, $c = 1\,000\,000$ and $t = 12$, $Q = 15\,000$ gal., which is the amount required for one washing.

$$Q_d = \frac{npc}{100} \tag{5}$$

when n = the number of filter units. All values of Q are in gallons.

Now where a separate pumping plant for wash water is to be used, if there is no storage, the pumps must have a daily capacity equal to or greater than $1440\ Q_m$. If we have storage equal to Q_w, the daily capacity must be not less than Q_d. Q_w is, of course, the minimum for storage capacity in that case.

Let $n = 10$, $p = 3$, $c = 1\,000\,000$; then $Q_d = 300\,000$ gal. per day. If $Q_m = 5550$, $1440\ Q_m = 8\,000\,000$ gal. per day.

We may then have an 8 000 000-gal. pumping plant without storage or a 300 000-gal. plant with 15 000 gal. storage. In the above it is assumed that only one unit will be washed at one time. Q_d is independent of the size of the unit, but Q_m and Q_w will increase in proportion to the size of the unit. It is easily seen that, in the special case given, a 4 000 000 gal. pumping plant with not less than 7 500 gal. storage could be used for wash water, or other combinations could be made.

The value Q_m fixes the size of our piping and valves for wash water, while the number of valves and connections is determined by the number of filter units. The combined capacity of the wash water pipes and connections is fixed by the total capacity of the filter plant and is independent of the size of the units. To put it another way, the combined capacity of our wash water connections is nQ_m in gallons per minute. The question is, then, which is more economical for both first cost and operation, ten 20-in. valves or a number of 30-in. valves having equivalent total capacity. It is probable that up to 36 in. the larger sizes will be more economical. It should be borne in mind that the first cost of valves and connections is a very important factor in mechanical filters.

The head required for actual washing is low and is, therefore, small compared with that for conveying and distributing the wash water. When we consider the great first cost of piping, valves, etc., and the small proportion of the work put into the wash water that is actually used, it appears that, in some aspects, the process of washing is a very inefficient one. This brings the thought that there may be here a field for profitable study leading to important savings. The point is that some cheaper way

should be found of bringing the necessary amount of filtered water back under the filter bed with pressure sufficient for washing. It may be noted here that the volume of water used in a washing is usually from one to three times the volume of the sand in the bed.

At the new Cincinnati plant there are for wash water, two centrifugal electrically operated pumps, capacity 25 000 gal. per minute each, and a storage reservoir on the hill 400 ft. distant of 190 000 gal. capacity. This storage is more than enough for two washings, while at the same time the pumping plant has twice the capacity required for washing.

The distribution of the wash water is a matter in which the size of the filter unit is an important factor. It is necessary that the wash water be made to rise uniformly through the entire bed. The difficulty of doing this evidently depends upon the ratios that the length and width of the sand bed bear to its depth. As the water will follow the line of lowest resistance it is necessary to make the resistance equal for all parts of the bed. Time will not permit our going into a detailed discussion of how this is done, but it may be noted that a new idea was tried in the Cincinnati plant. The wash water enters through perforated brass plates in the bottom of longitudinal concrete troughs which are filled with gravel. To guard against possible rising of the gravel the troughs are covered with brass wire netting above which is the sand bed. This netting is the novel feature. (See Fig. 2.)

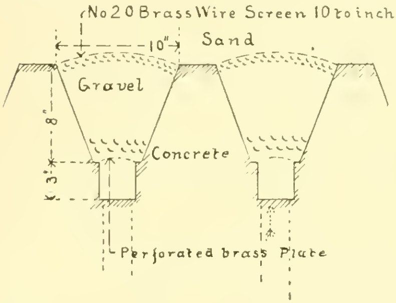

FIG. 2. — SKETCH CROSS-SECTION OF STRAINER SYSTEM AT CINCINNATI.

The pressure under such a strainer system as this is a matter of interest. The pressure must be sufficient to cause the sand to rise and be suspended by the current.

Let D = The specific gravity of a particle of sand,
and V = Volume of the voids in 100 volumes of sand;
S = Depth of sand bed in feet
H = Extra head in feet to raise sand.

$$H = \frac{(100 - V)(D - 1)S}{100} \qquad (6)$$

Let $V = 30$, $D = 2.6$, and $S = 2.5$.
Then $H = .70 \times 1.6 \times 2.5 = 2.8$ ft.

To see if the theory of formula (6) is correct, an experiment was made last year on a large filter under the direction of the writer. A glass gage was connected below the sand and the pressure was observed with an increasing upward flow of water. The difference in level of the water in the gage tube and that over the sand showed the lifting head. This head increased as the flow of water and without raising the sand until the critical head was reached, when the sand began to rise in spots. The measured head at this point substantially agreed with that shown by formula (6). Further increase in the flow did not materially increase the head.

ERRATA.

1909 June Journal, Vol. XLII, No. 6.

Page 328 – 6th line from the top, for 25 000 read 2 500.

In the same paragraph omit the last clause after the word *washings*.

Page 331 – Table I, 2d line, width of filter unit in feet for Cincinnati, for 32 read 28.

Table II, date of installation for Cincinnati, for 1908 read 1907.

Same table, rate of filtration for Cincinnati, for 110 read 125.

Page 332 – 14th line from bottom, for 65 000 read 85 000.

filtering. The work in horse-power hours consumed for wash water in existing plants is far greater than this would indicate, however, for reasons already noted.

Agitation with air is used in many plants to assist washing. Air is forced under the bed and flows up through the sand and water. It is evident that the pressure must be not less than that due to a head of water equal to the depth of the sand. In practice about 3 lb. per sq. in. in the supply pipes is used. From 2 to 3 cu. ft. of air per sq. ft. of filter per minute is furnished.

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It may be said by way of rough measurement that the extra head necessary to put the sand in suspension is, for ordinary sands, approximately equal to the depth of the sand.

As a filter cannot be properly washed without suspension of the sand, it is clear that the wash water must be supplied under sufficient pressure to provide this extra head at all points. This is an important factor in the design of the strainer system for beds of large area, but for lack of time, as stated above, we will only make this brief mention of it. Some differences in the strainer system details of individual plants will be noted later, and in the bottom lines of Table I will be found further data in this connection.

It may be said that the head required for actual washing is approximately equal to the depth of the sand and, as noted before, we see that the work done in actual washing is small. It is known that the head lost in filtration through ordinary filter sand at 3 in. per minute is about two thirds of the depth of bed when the sand is clean. As the head of filtration may run as high as 8 to 12 ft. or more as the bed becomes clogged, it may be said that the head of washing is about one third of the head for filtering, and if we are using 3 per cent. of wash water, the work of actual washing is probably less than 1 per cent. of the work of filtering. The work in horse-power hours consumed for wash water in existing plants is far greater than this would indicate, however, for reasons already noted.

Agitation with air is used in many plants to assist washing. Air is forced under the bed and flows up through the sand and water. It is evident that the pressure must be not less than that due to a head of water equal to the depth of the sand. In practice about 3 lb. per sq. in. in the supply pipes is used. From 2 to 3 cu. ft. of air per sq. ft. of filter per minute is furnished.

The uniform distribution of the air is, of course, a most important consideration. Now the resistance to flow of the strainer system must affect the distribution. In the bottom lines of Table I are given data indicating the comparative resistance of strainer systems to air.

It is probable that the net work of cleaning the sand is about the same with air agitation as when washing is done with water alone. About 3 000 cu. ft. of air for each agitation is required for a 1 000 000 gal. unit. In some plants the air is stored in tanks under high pressure. Less horse-power in engines and boilers is thus required, but the efficiency is also reduced.

Experience has not yet demonstrated which is more economical or advantageous in operation, agitation with air or a high rate of washing without air. In the matter of first cost, too, it is still an open question which system has the best of it. Where air is used as in Harrisburg, however, without a separate pipe system, the first cost of the air plant is low, but, on the other hand, it is doubtful if a good distribution of air is thus obtained.

The design of the trough system above the sand bed to carry off the waste water while washing is an important matter. In the first place it is difficult to compute the true discharging capacity of a trough receiving water all along its length. In all plants seen in operation by the writer the troughs were more or less deficient in this respect. The actual capacity was less than the flow for which they were designed. On the other hand, too much excess capacity is undesirable. At each washing the volume of water in the trough system is wasted without useful effect and hence this volume is equivalent to clearance or lost motion.

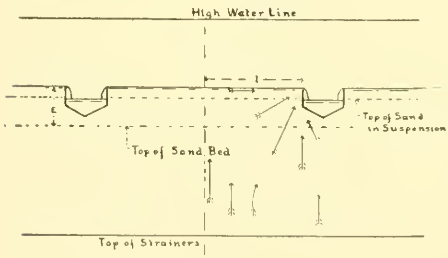

FIG. 3.

SKETCH SHOWING TROUGHS FOR WASTE WATER.

Arrows show direction of current while washing.

As to elevation of troughs, experience indicates * that the sand, when in suspension, rises to a height approximately equal to the upward velocity of the wash water. If the troughs are set too low, the sand will be lost. If they are set too high, so much more

* Mr. Benzenberg, of the Cincinnati plant, stated that his experiments proved this to be true.

water is required at each washing to obtain the same effect, as only the wash water that goes through the troughs is effective in carrying out impurities.

In good practice the troughs are spread not more than 6 to 7 ft. apart, as shown by maximum travel to trough, Table I (the distance l, Fig. 3).

TABLE I.

Details of Filters Proper.	New Orleans.	Columbus.	Cincinnati.	Hackensack Water Co.	Harrisburg.	Little Falls.	St. Louis (proposed).
Length of filter unit in feet	53	27.67	50	46.67	26	24	80
Width of filter unit in feet	27	46.67	32	25.8	16	15	44
Depth of sand in feet	3	2.5	2.5	2.5	2.5	2.5	4
Height of weir above sand in feet (E, Fig. 3)	2.5	1.0	2.5	1.0	1.33	1.0	1.17
Maximum travel to trough in feet (l, Fig 3.)	2.44	3.2	3.5	3.2	3.4	3.5	3.5
Available positive head on strainers	10		5.5			7	
Available negative head on strainers	8.5		2.5			3	
Available total head for filtration	18.5		8		8.5	10	
Depth of water on sand in feet	6.5	4.2	3.0	4.17		4	4.5
Effective size of sand (millimeters)	0.35	0.38	0.34	0.42–0.50	0.38	0.40	
Area of strainer openings (per cent.) water		0.18	0.34	0.145	0.21	0.29	0.10
Area of strainer openings (per cent.) air	—	0.023	—	0.023	0.21	0.018	
Loss of head in feet at strainer openings:							
Filtering			0.05		0.15		
Washing			3.7		1.5	0.65	
Air			—		0.02	6.2	

The area of strainer openings is the net area or waterway and is given in per cent. of the filtering area. The loss of head given in the last three lines is computed with the coefficient of efflux for orifices in thin plates. For air the loss of pressure is measured in feet of water. All values are approximate only.

TABLE II.

Main Features of Filtration Plant.	New Orleans.	Columbus.	Cincinnati.	Hackensack Water Co.	Harrisburg.	Little Falls.	St. Louis (proposed 1902).
Date of installation, approximate	1909	1908	1908	1904	1905	1902	1902
Capacity of plant, million gallons per day	40	30	112	24	12	32	120
Capacity of 1 unit, million gallons per day	4	3	4	3	1	1	5
Number of units	10	10	28	8	12	32	24
Rate of filtration, million gallons per acre per day	125	120	110	120	80–120	125	63
Rate of washing, inches per minute flow	30		24		9	9	
Agitation	—	Air	—	Air	Air	Air	Air
Air for agitation, direct pumping or stored	—	Stored	—	Direct	Direct	Direct	
Wash water, direct pumping or stored	Stored	Stored	Stored		Direct	Direct	
Time of settling, without coagulants	1 hr.	—	48 hr.	—	—	—	24 hr.
Time of settling, with coagulants	7 hr.	12 hr.	5 hr.	12 hr.	8 hr.	1¼ hr.	12 hr.

The waste pipe system that takes the wash water with its load of impurities away to the point of disposal may be a matter of some moment. Its required capacity may be computed in the same way as the wash water supply pipes. In most plants the waste pipes are of no great length, but where the filter plant is placed a long distance from a suitable water course the waste pipe system may add a large item to the cost. In such a case, as the discharging capacity must be proportional to the size of the filter unit, the general design of the plant may be materially influenced. Moreover, it may be noted that in such a case agitation with air would have a distinct advantage over a high rate of washing without air.

We will now consider actual practice as to some of the matters above referred to. The writer had opportunity to see in actual operation the mechanical filter plants at Cincinnati, Little Falls, N. J.; New Milford, N. J.,* and Harrisburg, Penn. In all these plants rectangular gravity filter tanks of concrete are used. In each plant the writer saw the operations of washing carried out.

At Cincinnati the Ohio was in flood and the raw water very turbid. Only one of the primary settling basins was complete and in use. All the coagulating basins were in service. One and one-quarter grains lime and 2½ gr. sulphate of iron per gallon were being used, and most of the sediment was removed in the basins before reaching the filters.

With bad water, the filters were washed twice in twenty-four hours. Filtered water was used for washing. They were washed for one-half minute at less than half rate, then four minutes at a 2-ft. per minute rate. Washing was stopped before the wash water was clear. Each washing took about 65 000 gal., and it was said that the consumption of wash water sometimes ran as low as 2 per cent. As the writer remembers, the small troughs were over-loaded while washing, but the collecting drain had excess capacity. The sand was completely in suspension at the 2-ft. rate. The washing was not, however, equally vigorous all over the bed. It was better at the end of the filter nearest to the wash water supply main. This indicates that the friction in the distributing pipes under the filter is considerable. The filtered water was beautifully clear.

This is the largest mechanical filter plant in the world, and the first large filter plant for highly turbid water in the United States.

At the Cincinnati plant all gates for washing are operated by electric motors. They seemed to work well.

* Belonging to the Hackensack Water Co.

For regulating the charging of coagulants, a special alarm clock is used which strikes at regular intervals. The length of the periods can be quickly altered by changing the transmission gears.

The controlling device used for regulating flow is of a new type. An independent hydraulic motor is used to move the valve proper, giving a very close automatic regulation. The filters of this plant are entirely within the filter house, which makes inspection of them more attractive than in other plants.

At Little Falls agitation with air is used. By a system of trapping, the air is made to pass through a smaller orifice than the wash water at each point in the strainer system. When the filter is ready for washing, the water is drawn down about 6 in. below the trough weirs and the air turned on. The air is blown at a rate of 1 500 cu. ft. per minute for three minutes. The pressure at blower is 2½ to 3 lb. per sq. in. The agitation lasts three minutes and appears to be very vigorous. The wash water is then turned on and the bed is washed at a rate of 9 in. per minute upward flow. All valves for filters are operated by hydraulic cylinders. To run the filter plant, the superintendent and six men are on the day watch and two men only on night watch.

The Hackensack plant at the time observed was running at some disadvantage as the only settling basin was out of use and being cleaned. While speaking of this, it may be noted that this basin was at such a low elevation with respect to the river, which was considerably above low stage, that the drain pipe would not carry off the mud and water, which stood over knee deep in the middle of the reservoir. Cleaning was, of course, slow and expensive. About 2 ft. of pasty mud had accumulated in two and one-half years.

While the basin was out of service the raw water flowed on to the filters immediately after receiving the coagulant, making extra work for the filters. In the filters here the strainer system is of perforated plates at the bottom of square hopper-shaped chambers of concrete filled and covered with gravel, the purpose being to leave no dead space that might become foul. The air is brought by an independent set of perforated pipes above the gravel. The writer saw one filter washed and noted that the air agitation was not uniform throughout the bed. It was said, however, that this particular filter was the only one that gave trouble. In the plant as installed, the air for agitation was furnished by air compressors and tanks for storage under 150 lb. per sq. in. pressure. A positive rotary blower is now used

instead. All filter valves are operated by hydraulic cylinders. The plant was running at its full rated capacity at the time visited.

At Harrisburg the water is prepared for filtration by first adding one half of the coagulant, then settling eight hours, then adding the rest of the coagulant and settling one hour. When the water is bad only three eighths of the coagulant is added for the first treatment. It is thought that if this treatment were preceded by three hours' settlement without coagulant, better results would follow. The filters are washed when the head of filtration reaches $3\frac{1}{2}$ to 5 ft. The head is never allowed to exceed $8\frac{1}{2}$ ft. A unit is never run over twenty-four hours without washing, although it could be run forty hours when water is good. When the water is cold the runs are shorter. At such times a filter is washed as often as five times in twenty-four hours.

The washing rate is about 9 in. per minute and the troughs are overloaded, so that the best effect is not obtained. It is thought that better results could be had with a 12-in. rate and deeper troughs.

These filters have a very simple strainer system of perforated pipes. The air and water take the same course. The writer noted that the air is not well distributed at the beginning of agitation. The distribution gradually improves, however, and at the end the air is coming up all over the bed, although still stronger in spots. The agitation lasts three minutes, with about 1 000 cu. ft. per minute, which is about 2.3 cu. ft. air per sq. ft. per minute, and with 2 lb. air pressure at blower. One filter was drawn down after washing so as to expose the sand. There were irregular areas of clean sand and areas covered with a dark deposit about $\frac{1}{4}$ in. thick. Washing without air has been tried without any apparent loss of efficiency, but it was not thought prudent to continue the practice. No storage is provided for wash water or for air. The waste water has to be disposed of by pumping when the river is high. All filter valves are operated by hydraulic cylinders. They give satisfactory service. The records show that these filters have given excellent bacteriological results.

The writer also visited the filter plant at Columbus which at the time was nearing completion. It is intended to soften and purify the water. Lime and soda ash solution will be used and if necessary sulphate of alumina will be added. The strainers are perforated plates in the bottom of concrete troughs, filled with

gravel.* Air is supplied through separate pipes as at the Hackensack plant. Storage is provided for both air and wash water. Air is stored at 60-lb. pressure in overhead tanks in filter house. The expectation was to wash two to three minutes, then agitate, then wash two to three minutes again.

The new filter plant at New Orleans was under construction last year. The writer did not visit the plant, but was interested in learning its general features. The washing system is much like that of Cincinnati. No air agitation, but a high rate of upward flow, is used, and the gravel is held down by wire screens. The wash water supply system has new features. The wash water is stored in long steel tanks extending overhead above the pipe gallery. These tanks are connected to an air receiver under pressure. There are no wash water pumps. The wash water is drawn from the high pressure pump mains.

In Tables I and II are given dimensions and data of the mechanical filter plants above referred to. There have been included also similar notes of a mechanical filtration plant that was designed for St. Louis about eight years ago. This scheme was proposed by Mr. Edward Flad, then water commissioner. The writer assisted in making the design.

The plans are shown in some detail in the report of the water commissioner for the year ending April, 1902. Air agitation was included with separate air distributing pipes enclosed in the collecting pipes for water. The details present many novel features. Special effort was made to secure a good distribution of air and wash water on account of the great size of the filter beds. No gravel was to be used, as the writer remembers.

In addition to mechanical filter plants, the writer visited about a year ago the slow sand filtration plant at Pittsburg and the experimental plant in Jerome Park, New York. At the latter place the writer saw some test runs made with the Blaisdell patent filter washing machine. This machine is electrically driven and travels over the sand bed, raking the surface and washing away the impurities. From 2 to 18 in. in depth is washed. It seemed to do good work on a filter bed 15 ft. wide. Machines of this character would be used for filter plants of Class III mentioned near the beginning of this paper.

At Pittsburg the new plant was in operation. The water supplied to this plant has at times proved to be more difficult of

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* The troughs are narrower and shallower than those shown in Fig. 2 and there is no wire netting above the gravel.

filtration than was expected. At such times a rate of only 1 000 000 gal. per acre per day is obtained. There are forty-six units of one acre each. The writer took a special interest in the electrically driven machinery which was on trial for scraping and washing and restoring the sand to the filters.

For much of the information given herein the writer is indebted to the courtesy of parties connected with the plants, among whom may be mentioned Messrs:

Geo. H. Benzenberg, Acting Chief Engineer, Cincinnati; J. W. Ellms, Superintendent Filter Plant, Cincinnati; Geo. W. Fuller, Consulting Engineer and Filtration Expert; Wm. B. Fuller, Engineer in Charge of Experimental Filters, Jerome Park; Geo. G. Kennedy, Superintendent Water Works, Harrisburg; Morris Knowles, Chief Engineer Bureau of Filtration, Pittsburg; John H. Gregory, Engineer in Charge Improved Water and Sewerage Works, Columbus; G. E. Howe, Resident Engineer Filter Plant, Columbus; Geo. P. Baldwin, Blaisdell Company; Geo. G. Earl, General Superintendent Sewerage and Water Board, New Orleans.

Printed descriptions of the plants referred to, with illustrations, may be found in the following periodicals:

Cincinnati, *Engineering Record*, April 6, 1907; New Orleans, *Engineering Record*, August 31, 1907; Columbus, *Engineering Record*, February 24, 1906; Harrisburg, *Engineering Record*, March 9, 1907; Hackensack, *Engineering Record*, November 12, 1904; Little Falls, *American Society Civil Engineers Transactions*, Volume I, page 394; Pittsburg, *Engineering Record*, December 8, 1906; Blaisdell Patent Filter Sand Washing Machine, *Engineering News*, March 12, 1908.

[NOTE. — Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by September 15, 1909, for publication in a subsequent number of the JOURNAL.]

GAGE MEASUREMENTS OF SERVICE CONNECTIONS OF THE ANCIENT ROMAN WATER-WORKS.

By M. L. Holman, Member of the Engineers' Club of St. Louis.

[Read before the Club May 5, 1900.]

The water supply of Ancient Rome is an interesting study for the engineer and archæologist. Several papers have appeared in the Journal of the Association of Engineering Societies treating of various phases of the subject. In 1899 Mr. Clemens Herschel published the result of his researches and investigations in a book entitled "Frontinus and the Water Supply of the City of Rome." Water was supplied to the city through aqueducts, which, in turn, supplied tanks from which the water supplied to the consumers was controlled by a bronze "calix" or ajutage. The Latin manuscript (photographic copies of which are published in "Frontinus") as translated gives the dimensions of the various ajutages used.

Students of the subject seem to have taken it for granted that the dimensions and results of computations as they appear in the manuscript and its translations are, to use the footnote on page 31 of the book, "a hopeless confusion of figures." The footnote on page 27 is, "It is useless to try to test the computations of Frontinus himself from the data now available." It is for the purpose of contributing to the solution of this question, and for the further purpose of bearing witness to the correctness of the computations of the hydraulic engineers of Rome, that this paper is written. The conclusions are based on the translation given in "Frontinus."

The method of controlling the flow of water to the consumer was that practiced in irrigation, and the practice extends from the earliest historical times to the present day. It is a case of the survival of the fittest. The practice referred to is the control of the rate of flow. The rate of flow is the important item to the irrigator: the quantity of water used varies with the land, the crop and the season, but in order to get his work done properly the irrigator must have a rate of flow that will handle the work. As the use of water was extended to houses and cities the same idea was carried out, probably as a necessary sequence and

possibly to avoid discrimination, and the rate of flow to the consumer was fixed by the calix or ajutage issued to him.

In taking up the problem before us, it will be necessary to examine into some of the methods by which the computations may have been made. In my first examination of this problem, I was inclined to agree with former critics. It occurred to me to make a further effort and to confine my mathematical efforts to the field of arithmetic only.

Paragraph 24 on page 25 of "Frontinus" is as follows:

"The adjutages to measure water are arranged either according to digits or inches. Digits are used down to the present day in Campania and in many places in Italy; inches in Apulia and elsewhere. The digit, according to common agreement, is the one-sixteenth part of a foot, the inch the twelfth; but even as there is a difference between the inch and the digit, so also digits differ among themselves; some are called square, others round. The square digit is greater than the round digit by three fourteenths of itself; the round digit is smaller than the square digit by three-elevenths, obviously because the corners are lopped off."

We see from this paragraph that the foot was divided into sixteen parts, or digits, and into twelve parts, or inches. Frontinus used the digit as the unit for measuring the calices and divided the digit duodecimally and binarily. The limit of precision used by him was 1/288 of a digit, and fractions of this limit are occasionally given. This limit is divisible by 1/16 and 1/12. The following multiplication tables illustrate the handiness of this fraction, viz.:

	1/2	1/12	1/24
1/2	3/12	1/24	6/288
1/12	1/24	2/288	1/288
1/24	6/288	1/288	1/2 of 1/288

	1/2	1/4	1/8	1/16
1/2	3/12	3/24	1/4 + 6/288	9/288
1/4	3/24	1/24 + 6/288	9/288	4/288 + 1/2 of 1/288
1/8	1/4 + 6/288	9/288	4/288 + 1/2 of 1/288	2/288 + 1/4 of 1/288
1/16	9/288	4/288 + 1/2 of 1/288	2/288 + 1/4 of 1/288	1/288 + 1/8 of 1/288

The number 288 is interesting in availability for binary and duodecimal work:

$288 = 2 \times 144$	$288 = 2 \times 144$	$288 \times 5 = 1440$
4×72	3×96	$\times 6 = 1728$
8×36	6×48	$\times 72 = 144 \times 144$
16×18	12×24	
32×9	24×12	
64×4.5	48×6	
128×2.5	96×3	
256×1.125		

The next point to determine is the ratio of circumference to diameter used by Frontinus. This ratio has been discussed with many pros and cons, but the statement of Frontinus himself seems to have been overlooked. To quote again from paragraph 25: "The square digit is greater than the round digit by 3/14 of itself"; that is, $14/14 - 3/14 = 11/14$, and "the round digit is smaller than the square digit by 3/11"; that is, $11/14 + 3/11$ of $11/14 = 1$. This plain statement of the $\frac{\pi}{4}$ ratio leaves no doubt as to what Frontinus used for the value of π; it was 22/7. And the value used for $\frac{\pi}{4}$ was 11/14.

Frontinus used mixed numbers, and the fractions most used were 1/2, 1/12, 1/24, and 1/288.

The unit ajutage was 5/4 of a digit in internal diameter and 12 digits long, and the rate of flow through the orifice was a quinaria. The orifice itself as well as the rate of flow seems to have been called a quinaria.

Following the order in which Frontinus takes up the discussion of the ajutages, let us first consider the inch ajutage, the square digit and the circular inch, using the quinaria as the unit. It must be borne in mind that the object of the writer is to show the accuracy with which a mass of figures has been handed down to posterity and not to discuss the hydraulic problems involved, or the extent of the knowledge of hydraulics in ancient times. The quinaria used to designate the rate of flow was similar to our miner's inch. It was simply an easy practical unit for distributing water among a number of consumers.

The inch being the twelfth part of a foot, and the digit the sixteenth part, one inch was equal to one and one-third digits. The inch ajutage being 4/3 digit in diameter, its area in circular units was 16/9. The quinaria was 5/4 digit in diameter and its area in circular units was 25/16; hence the number of quinaria in a

circular inch was 16/9 divided by 25/16, or 256/225, which reduces as follows:

```
          256
          288
        -----
         2048
        2048
        512
       ------
225)73728(327
     675      288 equals     1    quinaria.
     ---      ---
     622       39
     450       24   ,,      1/12      ,,
     ---       --
     1728      15
     1575      12   ,,      1/24      ,,
     ----      --
      153       3   ,,     3/288      ,,
       12
      ---
      306
      153
     -----
225)1836(8          ,,      (8/12) (1/288) quinaria.
    1800
    ----
      36 equals (36/225) (1/12) (1/288) quinaria.
```

Dropping the final fraction the result is that the inch ajutage contains $1 + 1/12 + 1/24 + 3/288 + (8/12)(1/288)$ quinaria, which agrees with the text of paragraph 38. The value as given is within one part in 21 600, a precision fully as high as the subject warranted. Frontinus and his computors were not justified in extending their computations beyond practical limits any more than the engineers of the present day are justified in making all computations to seven places.

The square digit: The diameter of a circle of one square digit area was considered to be $\sqrt{14/11}$, the area in circular units was 14/11 and the quinaria contained was 14/11 divided by 25/16 or 235/288 of a quinaria. The text gives 10/12 of a quinaria. The error is 1/72 of a quinaria and may be due to a copyist's or a translator's mistake.

The circular digit having an area of 1 in circular units contained 1 divided by 25/16 or 16/25 of a quinaria, or $7/12 + 1/24 + 1/72$ as given in the text of paragraph 38, and the error is 2/25 of 1/72 or 1 part in 2 700.

We may now take up the ajutages in regular order as given in paragraphs 39 to 63.

The ajutages from the 5 pipe, or quinaria, up to and including the 15 pipe were designated by the diameters, the unit being 1/4 of a digit.

Table giving quinaria contained:

Pipe.	Diameter in ¼ Digits.	Area in Circular ¼ Digits	Quinaria in Fractions.	Quinaria Mixed Numbers.
5	5	25	1	1 quinaria
6	6	36	36/25	1 + 5/12 + 7/288
7	7	49	49/25	1 + 1/2 + 5/12 + 1/24
8	8	64	64/25	2 + 1/2 + 1/24 + 5/288
10	10	100	100/25	4
12	12	144	144/25	5 + 1/2 + 3/12 + 3/288
15	15	225	225/25	9

All of the values thus found are those given in the text and all are correct to the nearest 1/288 of a quinaria.

We may now tabulate the circumference of the smaller ajutages as follows:

Pipe.	Diam. in ¼ Digit.	Diam. in $\frac{1}{288}$ Digit.	Circumference. Fractions.	Circumference. Digits.
5	5	360	22/7 of 360/288	= 3 + 1/2 + 5/12 + 3/288
6	6	432	22/7 of 432/288	= 4 + 1/2 + 2/12 + 2/288
7	7	504	22/7 of 504/288	= 5 + 1/2
8	8	576	22/7 of 576/288	= 6 + 3/12 + 10/288
10	10	720	22/7 of 720/288	= 7 + 1/2 + 4/12 + 7/288
12	12	864	22/7 of 864/288	= 9 + 5/12 + 3/288
15	15	1 080	22/7 of 1,080/288	= 11 + 1/2 + 3/12 + 10/288

All of these circumferences are identical with those given in Frontinus and all are correct to the nearest 1/288 digit.

For the 20 pipe and larger sizes the designation of the pipe was the area of the cross-section of the calix in square digits. The 20 pipe had an internal circular cross section of 20 square digits. The 25 pipe had an area of 25 square digits, and so on for the larger pipes.

To show the accuracy with which the computations for the pipes larger than the 15 pipe have been handed down to the present time, we will now check the figures giving the quinaria contained. If we let "A" represent the area of the cross-section of an ajutage in square digits, the area in circular digits will be

14/11 A. The quinaria contained will be $\frac{14/11\,A}{25/16}$ or 224/275 A, and this reduced to units of 1/288 digit will be $\frac{224 \times 288\,A}{275}$.

We may now tabulate as follows:

Pipe, also Area in Sq. Digits.	Quinaria in Units of $\frac{1}{288}$ Quinaria.	Quinaria Contained.
20	4 692	16 + 3/12 + 1/24
25	5 865	20 + 4/12 + 9/288
30	7 038	24 + 5/12 + 6/288
35	8 211	28 + 1/2 + 3/288
40	9 384	32 + 1/2 + 1/12
45	10 556	36 + 1/2 + 1/12 + 1/24 + 8/288
50	11 729	40 + 1/2 + 2/12 + 1/24 + 5/288
55	12 902	44 + 1/2 + 3/12 + 1/24 + 2/288
60	14 075	48 + 1/2 + 4/12 + 11/288
65	15 248	52 + 1/2 + 5/12 + 8/288
70	16 421	57 + 5/288
75	17 594	61 + 1/12 + 2/288
80	18 767	65 + 1/12 + 1/24 + 11/288
85	19 940	69 + 2/12 + 1/24 + 8/288
90	21 113	73 + 3/12 + 1/24 + 5/288
95	22 286	77 + 4/12 + 1/24 + 2/288
100	23 459	81 + 5/12 + 11/288
120	28 151	97 + 1/2 + 2/12 + 1/24 + 11/288

The tabulated values check to the nearest 1/288 with the text of Frontinus, excepting the 65 and the 85 pipe. The record of the 65 pipe is evidently a copyist's mistake and it is the only one found. The 85 pipe differs by 2/288. The difference of 1/288 may arise from the different methods of calculations and correspond with our present differences of 1 in the last decimal place.

Paragraph 34 of Frontinus indicates that the results of the computations of the quinaria were adjusted in series in order that the quinaria contained in the different ajutages might have the proper relation to each other. This adjustment would account for a number of the slight differences which exist.

The computations for diameters and circumferences show no differences greater than 3/288 of a digit, and in most cases agree exactly with the text.

Frontinus recounts, at some length, the practices of the "Water Men" and shows the differences in gaging of four of the pipes, viz., the 20, 100, 120 and the 12 pipes. After some study of the record it seems that the 20, 100, 120 ajutages in question were gaged on the old system, as used for the smaller pipes, that is, by the diameters and not by the areas. Probably the new system was not in universal use at the time Frontinus wrote. In other words, the old ajutages had not been replaced to conform

to the new idea of gaging. I have thus far hit on no explanation for the difference in the 12 pipe.

It appears that the same differences between the law and the facts existed in the time of Frontinus that exist at present. The law generally establishes practical standards for everyday use and does not go into unnecessary refinements or deal in multiplicity of decimals. We see that by " edict of Cæsar " the 20 pipe had a legal gage of 16 quinaria; the 100 pipe, 81½ quinaria; and the 120 pipe, 98 quinaria.

The translation of the manuscript of Frontinus is well worth a careful reading by the student. The accuracy with which the arithmetical calculations have been preserved is remarkable. The further fact that the Romans had many of the same difficulties and contentions about " water rights " that we have to-day forcibly illustrates the unchangeableness of human nature. In checking over the different dimensions of the ajutages and in the computations for the quinaria contained, one must use arithmetical methods and think in fractions only. This is probably the reason why the impression got abroad that the work would not check out.

My object, as previously stated, is to testify to the arithmetical ability and the integrity of the records of the ancient hydraulic engineers. The only forum open for the defense of the ancient engineer is the Engineers' Club of the present, which is my justification for presenting the matter to you.

[NOTE. — Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by September 15, 1909, for publication in a subsequent number of the JOURNAL.]

THREE YEARS IN THE CANAL ZONE.

By Dr. Sumner Coolidge.

[Read before the Boston Society of Civil Engineers, November 4, 1908.]

Two professions are vitally interested in the success of the Panama Canal — the medical profession, to which the world turned for a solution of the health problem on the Isthmus; and the engineers, whose handiwork is expected to remove mountains and all lesser obstacles that stand in the way of the finished canal. I am not here this evening to attempt a scientific discussion of any phase of the Panama Canal, but to tell you of some of the incidents and impressions which go to make one of the most enjoyable and instructive experiences of my life.

The Northern public is always interested and generally well informed on canal matters, but when history is being made on the Isthmus so fast that those on the spot have difficulty in keeping up with the work, it is not to be wondered at if you in the North do not keep track of it all.

"What kind of a country is Panama, and how do you like it?" "How can you stand the climate?" "Isn't it awfully hot down there?" are questions asked repeatedly. The city of Panama lies close to the meridian of Buffalo, N. Y., and 9 degrees north of the equator, a latitude where one would expect to have a hot climate. Though not the narrowest part of the Isthmus from ocean to ocean, the strip through which the canal is to be dug contains the lowest point in the mountain range that forms the backbone of the two continents, and consequently the point where the least digging will be required to complete the canal. Of the entire distance of 47 miles between Colon and Panama, the line of the canal lies in swamps a little above sea level through about 17 miles.

The dry season begins early in December and continues till the latter part of April, during which time the refreshing trade winds from the northeast blow continually, the only variation being an occasional "Norther" which stirs up a dangerous Caribbean and cuts up interesting capers along the shore. The wet season is a time of many showers. Although 120 to 150 in. of rain fall in seven or eight months, all-day storms are not frequent and many of the nights are clear and beautiful. When the rain storms are long continued, giving insufficient time for

the "run-off," freshets result, in which the river may rise 30 to 40 ft. above its usual level. The rain does not prohibit any of the occupations, but amounts only to an inconvenience. The annual rainfall varies widely in different parts of this small Canal Zone, the records showing a somewhat higher total on the Atlantic side, — 63.16 at La Boes, 135 + at Mt. Hope, for fiscal year 1906–07.

The Canal Zone as we found it was as tropical as tropical could be, being densely covered from the swamps to the hilltops with a mass of vegetation that was for the most part impassable except through the narrow trails of the natives.

It has been said by one writing of Panama that "her men are without honor, her women without virtue, her flowers without fragrance and her birds without song." The casual observer, crossing the Isthmus by train, hurrying through the uninhabited parts, and seeing little but squalor in the negro villages where the trains stop, observes little of the beauty of the lilies, morning glories, orchids, passion flowers, palms and ferns that abound though nearly hidden by the rank growth of coarser plants. That song birds are there, too, I know by observation, but, like the fragrance of the flowers, the beauty of their song is hidden by the coarser voices of their kind, — the screeching of parrots and paroquets, which must have impressed the author of the above quotation. Perhaps his estimate of the men and women was influenced by the coarser qualities of the class he saw and heard most of, — but certain it is that standards of honor and virtue in Panama do not exactly coincide with our own.

The temperature ranges between 65 degrees and 90 degrees, and although the humidity is high, the heat is not so oppressive, even for physical exertion, as on our hottest days here in Massachusetts, while the nights are so delightfully cool that almost every one living in a well-ventilated house sleeps under a blanket throughout the year. Americans on the Isthmus have few complaints of the climate, for it amounts to twelve months per year of very agreeable summer weather,— and Americans thrive on it,— although summer weather becomes monotonous if too long continued.

The United States paid the Panama government $10 000-000 for the perpetual right of way through a strip of land called the Canal Zone 10 miles wide and 47 miles long; $40 000 000 to the French company for all of its rights and equipments; and a large sum for the stock of the Panama Railroad, the

ownership of which was one of the first essentials to the prosecution of the work. The treaty signed by the two governments gave the United States absolute control of the Canal Zone, but as the 10-mile limit would have included the two principal cities of the young republic, Panama, the capital, and Colon, the Atlantic seaport, these were excepted in the purchase, and in all matters except sanitation are governed by the Panamanians themselves. In the matter of sanitation, however, these cities are quite under our control. We have the right to promulgate and enforce all sanitary regulations deemed proper by the chief sanitary officer.

Although the enforcement must be accomplished and penalties inflicted by the local courts — in the early days often accomplished with difficulty — later developments have proved our treaty with the Panamanians to be an extremely well-executed document, at any rate from the United States standpoint. No doubt it granted us much more than would have been received from an older republic; in fact, more than we should obtain from the Panamanians themselves to-day, for they never have ceased to feel that they gave us a great deal more than they were willing that we should have.

In answer to your question, "What kind of people are the Panamanians?" I cannot better demonstrate than by telling you of their attitude toward us and the treaty, which of itself is the only excuse the world has for taking any notice of them. The human nature of the fellow who wanted to "have his pie and eat it too" is intensified in the Panamanians beyond all previous records in my experience. The fact that their two principal cities were being converted from sloughs of filth and pestilence to clean, up-to-date municipalities by the money and labor of the United States did not seem to mitigate their feeling that we were intruders, and their chagrin that they were not handling the money. It is an actual fact that arrests of American workmen by Panamanian police for slight or imaginary offenses while the streets of Panama were being paved and sewered became so frequent and so annoying as to threaten the entire suspension of these operations until the Panamanians could be brought to their senses and made to guarantee the protection of our workmen instead of annoyance. In both Panama and Colon in 1905 and 1906 Americans were frequently arrested and brutally clubbed when greatly outnumbered by Panama police, in some instances after they had reached the "calaboose."

On one occasion a group of young officers from one of our warships, on shore leave in Colon, were arrested, and after reaching the "calaboose" were severely clubbed. It was with difficulty, and only after much parleying, that a Canal Commission doctor obtained permission to send the unfortunate prisoners to the hospital for necessary surgical treatment of their wounds. I was present next morning in the little dirty, dingy room on a second floor on a side street of Colon, where these young men were arraigned before the district judge. The trumped-up charges were carefully written at the dictation of the so-called judge, and the prisoners, cut, bruised and bandaged, had stood up to hear the charges read, when, to our great delight, but to the dismay of the court, there appeared in the doorway, like an apparition, one of the finest specimens of our naval officers, in full uniform, sword and all. Having made his salute to the Court, without waiting for recognition, he stated that he had been sent by the commander of the ship to bring the young men on board and to say that if their presence on shore was necessary at any time the commander would be responsible for their appearance. This occurrence stirred the Americans on the Isthmus to such a bitter feeling that trouble seemed imminent. The commander of the ship would have been pleased to turn to and blow the town out of existence, but a little time and hot cables between Washington and Panama led to the whole matter being dropped abruptly. Likewise the arrogant insults of the Panama police.

The Canal Zone as we received it presented a spectacle that beggars description. The ravages of time in such a climate are rapid, and nature quickly covers all traces of man's activities when once they are suspended. The only signs of the white man's enterprise were on the line of the railroad and immediately connected with the business of that corporation, and the hundreds of locomotives, dump cars, excavators, cranes and other machinery, the dwellings, hospitals and shops, and the miles of railroad tracks abandoned to decay or to be overrun by vegetation suggested a graveyard of the most gigantic enterprise, or rather a monument to the most gigantic failure of a good cause the world has ever seen.

The Panama Railroad, always one of the best-paying railroads in the world, remains an anomaly in railroad history. Its stock is owned by the United States government, but the business is conducted, as is any railroad business, for profit, to pay interest on bonds still outstanding. Its president is the chair-

man of the Canal Commission, the several members of which are the directors of the road. Absolute control of this railroad by the Commission has made it possible so to arrange its business that all else is secondary to its service to the canal work. Passenger trains are run in the early morning, at noon and in the evening, to avoid the working hours of dirt trains and the great volume of through freight, which is still crossing the Isthmus on its way to the United States and Europe and is transported at night.

Of the many problems that confronted the pioneers of this great work none seemed more serious than the health conditions on the Isthmus. The story that tells of the death of a man for each tie used in the construction of the Panama Railroad in 1850–55 is only a slight exaggeration of the truth, and the havoc wrought by disease among the French in the period of their greatest activity has given the Isthmus a reputation which the whole world refuses quickly to forget.

When the first Canal Commission visited the Isthmus in May, 1904, before the property of the French Canal Company had been formally transferred to the United States government, a careful investigation was made as to the sanitary conditions — the population, the prevailing diseases and other necessary data — in the cities of Colon and Panama and also in the Canal Zone. In May, 1904, the population of Panama was 19 000; of Colon, 7 000, and of the villages within the Zone, 8 000, a total of 34 000.

In Panama there was no water supply except rain water from the roofs during the rainy season and water delivered by carts during the dry season. The lack of running water made it necessary for each householder to keep one or more barrels, cisterns or tanks in which to store a small supply of fresh water. There was likewise no sewer system except some antiquated underground drains constructed of stone by the earlier inhabitants.

In Colon the water supply was somewhat better, there being a small pipe line, owned by the Panama Railroad, which delivered a small quantity of fairly good water into that town. The better classes, however, continued to use rain water from cisterns. Two small sewers were in existence; one, the property of the Panama Railroad, the other of the Panama Canal Company.

Along the Canal Zone there was absolutely no provision for a water supply or sewerage system except at one or two

stations where the activities of the old French Canal Company had been such as to warrant the installation of a local water supply.

It will be observed that the water receptacles in every dwelling, and the swamps about the towns, afforded most favorable breeding places for the stegiomya and anopheles mosquitoes.

The French Canal Company had built a hospital at Ancon, a suburb of Panama, with a total capacity of 700 when crowded, and in the city stood the old city hospital known as Santo Tomas, with a capacity of about 350 beds. In Colon were two hospitals, — one of 35 beds owned by the Panama Railroad; the other of 50 beds owned by the French Canal Company. With the exception of the Railroad Hospital at Colon, all hospital buildings were out of repair and in an unsanitary condition. Nor was any attempt made to keep the buildings or grounds from deterioration, some of the wards at Ancon being entirely hidden from view by the tropical vegetation that quickly sprang up when the French activities began to subside.

The prevailing diseases were yellow fever, beri-beri, tuberculosis, malaria, pneumonia, typhoid and dysentery. Statistics of these diseases, which were kept during the operations of the French Canal Company, 1881–1904, not only suggest a picture of the awful havoc wrought by disease upon the working force, but afford a most interesting comparison with the methods and results of the later enterprise.

The French began operations in 1881, and in December, 1883, the total number of employees had reached 10 000. In October, 1884, the maximum of 19 000 was reached, and an average number of about 15 000 or 16 000 was maintained until 1888, when it fell rapidly, reaching 900 in September, 1889. A total working force of about 700 men was then continued on the Isthmus until 1895, when a feeble attempt was made to renew active work on the canal, but the total number of employees never exceeded 4 000. In 1884, of an average total of about 18 000 employees, the deaths numbered 1 232, an annual death-rate of 70.13 per 1 000.

From the beginning of the United States occupation it was recognized that the success or failure of the enterprise would depend not upon the solution of any engineering problems, complex as these appeared, but upon the outcome of the campaign against yellow fever. It had been noted that the introduction of large numbers of non-immunes into a country where yellow fever was endemic was invariably followed by an epidemic

of the disease, the severity of which varied in direct proportion to the number of non-immunes introduced, and it was well known that an epidemic would soon develop on the Isthmus after the arrival of the American workmen unless aborted by some means. The first step in the campaign against Isthmian diseases was the organization of a working force that would cover effectively and at once all parts of the field. To this end the Department of Health was made to consist of the following divisions:

1. Hospital Division, which attended to the sick and injured.

2. Sanitary Division, which instituted an active campaign against filth and mosquitoes; and

3. The Quarantine Division, whose duty it was to prevent the introduction of new sources of infection.

Hand in hand with this sanitary organization the Engineering Department created a division of municipal engineering which should at once proceed with the introduction of sewers, water supplies and paving, to make permanent the results of other sanitary measures. Of the sum total of sanitary procedures employed, the greater part had to do directly or indirectly with a war against mosquitoes. It had been learned by actual experiment in Cuba that yellow fever was transmitted only by a certain variety of mosquito (stegiomya), whose habits of life and propagation have become well understood, and it was the application of this knowledge in the campaign in Panama that produced the results which have amazed the world and of which we may justly feel proud. Briefly, the handling of the yellow-fever question was as follows: Cases were admitted to the hospitals promptly and screened for a few days to prevent the infection of mosquitoes in the wards that would transmit the disease to other men; the quarters from which cases were taken, and houses recently visited by them, were fumigated by the "fumigation brigade," to kill all mosquitoes that might have bitten the patient before he was admitted to the hospital, and a relentless campaign was carried on against this special mosquito in its breeding places by the stegiomya brigade, with the purpose of exterminating the species as nearly as possible.

This stegiomya mosquito, the transmitter of yellow fever, is rather domestic in its habits, preferring to live and breed in and about human dwellings; and when you consider that the entire water supply of the community was from open tanks,

barrels or tubs kept full by rain in the wet season and scantily supplied from carts in the dry season, you will appreciate the task of inspecting every water container in the city at least once every six days, and covering and spigotting those that might not be destroyed. This inspection of every room in every house was resented by many of the Panamanians as an intrusion, and they did not hesitate to obstruct the work repeatedly. Then, again, the delays in obtaining supplies as ordered were most disheartening in the early days. Orders of the chief sanitary officer were often cut one half or even more reduced, and shipments were exasperatingly slow after the goods were bought.

Through that trying period, April to August, 1905, when yellow fever claimed so many victims, when Mr. Wallace's resignation became the signal for an exodus from the Isthmus that well nigh assumed the proportions of a stampede, and when high officials on the Isthmus became so skeptical of the methods of the chief sanitary officer that they were ready to ask for his recall, his confidence in his ultimate success was unshaken, and the patience and courage with which he kept his shoulder to the wheel may well be remembered in these later days when there appears to be a disposition in some quarters to question his share of the credit for present conditions. The last case of yellow fever originating on the Isthmus occurred in May, 1906, and there is no danger of a reappearance except as an importation from some of the infected ports within a few days' sail of the canal. It is safe to say that over one half the physicians on the Isthmus to-day have never seen a case of yellow fever. The total number of cases since the American occupation was 246, with 83 deaths.

But, after all, yellow fever was not the disease that most interfered with canal operations, except that its high mortality (one third of all cases) alarmed employees and prospective employees. The disease that causes more loss of time among the workmen than all other diseases combined, and consequently the most important economically, is malaria, the severest types of which are found on the Isthmus. Malaria is also transmitted from man to man by a certain mosquito (the anopheles), whose habitat is in the vicinity of swamps and pools and slowly moving streams. The anopheles is everywhere in Panama, except where her haunts have been destroyed by the anopheles brigade. A peculiarity of this pest is that she does not fly far from her native haunts except in the pro-

tection of vegetation or buildings. The campaign against malaria, then, consists of cutting vegetation about inhabited dwellings for a distance of about 1 000 ft., perfecting surface drainage to reduce the number of breeding places, and oiling those waters that cannot be drained away, screening houses and administering prophylactic doses of quinine daily to those who are not sick. The general distribution of the mosquito that transmits malaria and the presence of the malarial parasite in the blood of 70–80 per cent. of the native population as determined by actual blood examinations, the only two conditions necessary for perpetuating the disease, is evidence enough that malaria will never be eradicated from the Isthmus, as was the case with yellow fever, but the sum total of anti-malarial procedures has so far reduced the prevalence of the disease that the sick rate among canal employees to-day is lower than in the United States Army and Navy, and as good as on any similar work in the North.

While yellow fever has caused the greatest alarm, and malaria the greatest loss of time, the disease that for months caused the greatest number of deaths among employees is pneumonia. Deaths from pneumonia among whites are very rare, but negroes seem to have not the slightest resistance and die of this disease with alarming rapidity. Fifty per cent. of all cases in negroes die.

The medical care of the great army of canal employees has been often amusing, occasionally exciting and always interesting. The West Indian negro is mild of temper, credulous, usually courteous and takes himself very seriously. He is only a child in his intellect and his emotions, and when treated as such is not a bad sort. He is a glutton for medicine, is made so truly miserable by his exaggeration of his little indispositions that his descriptions of his symptoms are as amusing as they are graphic. One poor fellow whose woebegone countenance looked as if he had never smiled approached me and, in a voice full of tears, said, "Doctor, in de mornin' I has dark eyes, and, doctor, a giddiness in ma head, and a neediness in my bowels." Another was not sick, but wanted some medicine for a cold. His only symptom was a slight stomach-ache, which he explained by saying, "Doctor, ah works in de water an ah takes cold in ma feet, an de cole abstrack up out of de feet and wind 'roun' de nabal." But nature has never suggested to him that he lay up a winter's store, or that he produce what he needs to eat; in fact, she lays it at his door and he needs but

to partake. He is attracted to the Isthmus by the prospect of high pay in the employ of the canal, but he has no notion of working hard or continuously.

In the winter of 1905-06 it became my duty to institute a daily inspection of all labor camps in Cristobal, and in making my rounds I was surprised at the number of men in camp during working hours. Some were sick, some informed me that they had "worked hard" the day before and needed "a little rest," and not a few (of English persuasion) answered my questions as to their reasons for not working in a most supercilious manner, "Ah didn't fawncy to work to-day, sah!" But there has been a great weeding out of dead wood among the negroes and they have profited by their compulsory education in diligence and hygienic living, so that as a body they are much more efficient than two or three years ago. I said *compulsory* education. At first they did not like the food we offered them and preferred a starvation diet, which they prepared for themselves and which made them an easy prey to disease; but when compelled to eat at Commission kitchens and to sleep in well-ventilated buildings, or lose their positions, their condition steadily improved and now, like children, they are happier for their little punishment. Besides about thirty thousand negroes there are some sixty other nationalities represented among the canal employees, the most efficient of which are the Spaniards and Italians brought from Europe by contract.

Beside the medical and the mosquito work of the Sanitary Department a large force of men was kept busy for over a year digging out and removing the accumulations of filth of many years, especially in Colon and Panama. Thousands upon thousands of cart loads of rubbish, garbage and other filth were removed from the narrow alleys and little back yards, where it had been thrown for years and left for nature to dispose of. One of our greatest offenses against the feelings of the natives was our open-air treatment of their dirty condition, which required the removal of the high, close fences with which they had surrounded their little dooryards with their disgusting accumulations. Up to the time that sewers were completed night soil was disposed of by the bucket brigade system in the cities, and by pit closets in less thickly populated districts.

While this sanitary work was going on, the division of municipal engineering made preliminary surveys for water supplies and sewers for Colon, Panama and for all important towns along the canal, beside providing distilled or sterilized drinking

water for all the white employees on the Isthmus. It was not necessary to lay pipes 5 or 6 ft. under ground to escape frost, and the work was pushed forward without delay, so that the city of Panama was ready to receive its water supply on July 4, 1906. About a year later the Colon water works were completed, and soon all the towns in the Zone had sewers and water supplies as good as the average town of the North. It has been found that the tropical streams of the Isthmus furnish excellent water supplies, which, although containing considerable organic matter, are palatable and safe. Bacteriological examinations of all water supplies are made weekly, and copper sulphate is used successfully to inhibit growth of algæ.

The source of supply for the city of Panama, a reservoir of 500 000 000 gal., is 13 miles inland toward the head waters of the little Rio Grande, whose lower valley is to form the southern end of the canal. The elevation of the reservoir is 232 ft. (its area, 65 acres), so that there is plenty of head for all except the higher buildings at Ancon Hospital. The 16-in. main, by which the water is brought to the city, is tapped by five small towns on the way, and through most of the distance lies on top of the ground or only slightly covered. The Colon water supply is about 4 miles from the city in the rather shallow basin of Brazos Brook, a reservoir 122 acres in area. Its capacity is 435 000 000 gallons, but as its high-water elevation is only 45.1, the water is pumped into a standpipe, from which it flows through a 20-in. main to the city. The water for both Colon and Panama is filtered through sand beds under pressure and is metered to the cities by Venturi meters and again metered to consumers, the difference between the Venturi reading and the total of service meter readings being the amount charged to the municipality. The water to consumers costs in Panama 25 cents per 1 000 gal.; in Colon, 40 cents. Hydrants are charged at $49.68 each. Besides the five hydrants there are curbstone taps, located two blocks apart, from which the poor may draw water without charge. These are paid for by the city. Sewers and water works, when completed, were handed over to the Department of Public Works, a branch of the Department of Civil Government. It is expected that water rates and sewer charges which are collected by this department will, in fifty years, reimburse us for the entire expense of the sanitation of Colon and Panama.

The construction of the Panama sewers was a simple matter, as there was plenty of grade to the ocean in several

directions, but in Colon was another proposition. Manzanillo Island, on which Colon is situated, is an old coral reef, the surface of which is only about 1 to 3 ft. above sea level, in consequence of which a considerable proportion of the sewer system is at or below sea level. Sewage is delivered into a sump in the center of the city, 27 ft. square and 21 ft. 6 in. deep, from which it is pumped through 1 115 ft. of 10-in. cast-iron pipe to a drainage canal leading to Manzanillo Bay. Surface water is carried directly to the sea, to the drainage canals, two of which have been cut across the island, admitting tide water to the swamps in the middle of the island. The maximum tidal wave at Colon is about 3 ft.; at Panama about 20 ft.

Closely following the installation of water pipes and sewers came the paving, the two divisions being in some instances only a few hundred feet apart. The principal streets were paved with vitrified brick on a concrete or macadam foundation; others were paved with concrete or macadam, and substantial concrete curbs and gutters were laid in all.

With the completion of sewers, water supplies and paving, yellow fever eradicated, malaria under control and no epidemic diseases to deal with, the first great step in Isthmian sanitation was accomplished, and since the later months of 1907 we have tried to maintain the favorable conditions then existing, improving here and there where found practicable. Since 1905 the annual death-rate of all employees has been reduced from 33.52 per 1 000 to 12.78 per 1 000; negro death-rate from 67.81 per 1 000 to 10.65 per 1 000; sick rate from 42 per 1 000 to 25.09 per 1 000; malaria, 400 cases less in September, 1908, than September, 1907.

The lateness of the hour forbids that I should dwell upon the every-day life of Americans on the Isthmus. Suffice it to say that out of what we called the "tin-can period," when we lived out of cans and jars, or at the local cantinas, there slowly developed a cold storage and ice plant, a steam laundry, a bakery, commission hotels and a well-systematized commissary, which, with the comfortable quarters, free electric lights, free running water, free coal for cooking and elaborate provision for social betterment make life on the Isthmus as comfortable as it is here at home. Wages are some 60 per cent. higher and the cost of living somewhat lower than in the States, and it is safe to say that there is no other place in the world where men can live so comfortably and at the same time save so much of their earnings as on the Isthmus of Panama. The employee

has always within his reach the means for intellectual, physical, social or spiritual improvement, and no one to dictate which he shall select. My own experience as leader of the band, whose concerts were of necessity given on Sunday afternoons; as chairman of the council of the Y. M. C. A., which rather frowns on Sunday dissipations; as president of the baseball association, which plays all its games on Sundays, and as family physician to the canal officials, gives you a sample of incongruous conventionalities reconciled by circumstances.

There are about 6 000 American employees at work on the canal, whose families aggregate some 2 000 women and children.

But time has flown and I have not told you anything about the "ditch." I believe that some of you here have asked me since my return, "What kind of a canal is it to be?" "Are they really making any progress?" "When will the canal be finished?" or "Will it ever be finished?" When I tell you that as great changes have taken place on the Isthmus of Panama in three years as have taken place in the average Massachusetts town in about three hundred years you will understand the confidence of all the men on the work in its early and successful completion. No one on the Isthmus wonders if the canal will ever be finished. On the contrary, they are wondering down there what their next job will be. The dirt is not "flying," but it is pouring out of the canal prism like a mighty stream. To one standing on the brink of the cut at Culebra, as he watches the sinuous movements of dirt trains winding their way out of the cut, it almost seems that the earth has taken life and is crawling away of its own accord. No digging is done by hand; rock is broken by blasting so as to be loaded by steam shovels, and is plowed from the long flat cars or dumped from dump cars in which it is transported.

With all our admiration for our own accomplishments in canal digging on the Isthmus we wonder more and more at the work accomplished by the French. With their diminutive excavating machinery, tiny locomotives and dump cars, handling a great deal of material by hand, they cut the Gold Hill to a depth of some 150 ft., tunneled hills to divert rivers, built a beautiful hospital and comfortable quarters for their employees and left many examples of the refinement of technical skill that characterizes all their work.

The canal is to be a lock canal, about seven miles at each end being at sea level, about four miles at an elevation of 55 ft.,

and some thirty miles at 85 ft. above sea level. The portion between Gatun and Bas Obispo will form a great lake through which vessels may steam at full speed in either direction for a distance of 23 miles, and the locks are to be constructed in duplicate, so that passage will be possible in either direction at all times.

That I am an enthusiast on Isthmian life and on the prospects of the canal I admit, and if you will accept my suggestion and take a winter trip to Panama you will come back as enthusiastic as I, although you will never be able to appreciate the changes that have been wrought there in the last three years. I should be pleased to have you come in contact with the source of my enthusiasm and be convinced, as I am, that the Panama Canal will be finished and in use before 1915.

DISCUSSION.

Chairman Johnson — In these days the men of the different professions are sharing more and more their glory with each other, but lately the physician has come to the fore and is taking the glory from everybody. We hear very little about the generals in the Japanese war and the war between this country and Spain, but we hear a great deal about the work of the medical departments. And now the glory of the most colossal piece of engineering done in the last century is going, too, to the physicians. They tell us — and unfortunately I am afraid it is true — that the work at the Isthmus could not have been carried on successfully were it not for the efficient work of the medical department. Boston has sent one man at least as a member of that medical department. He is now returned and we are fortunate in having him with us to-night to tell of the work of the Sanitary Department at the Isthmus.

We also have with us to-night Mr. Stearns, one of the consulting engineers who has served the Canal Commission from time to time. I think he needs no introduction.

Mr. Frederic P. Stearns. — There is very little I can add to what Dr. Coolidge has said, either on the engineering or the sanitary side of the question at Panama. It is always a pleasure, however, to express appreciation of the wonderful work that has been done by the sanitary authorities at that place, and I do not think it is very much of an overstatement, if it is at all an overstatement, to say that the work could not have been accomplished under the conditions that existed at

the time the French were on the Isthmus, particularly when they had their largest forces there. I looked up at one time the statistics of deaths in the city of Panama knowing, as Dr. Coolidge has stated this evening, that one could not depend upon the records of the death-rate of employees, because they represented only the employees who died in the Ancon hospital.

The statistics referred to show that during the five years from 1900 to 1904 inclusive, just before the United States took charge of work at the Isthmus, and when the New Panama Canal Company had only a small force on the work, the death-rate in the city was 62 per 1 000. This may be considered the normal death-rate in Panama under the conditions which then existed.

The French had their largest forces upon the Isthmus during the five years from 1884 to 1888 inclusive, and during these years the average death-rate was 106 per 1 000. The population of the city at that time was, undoubtedly, largely increased by the employees on the canal, and it seems fair to assume that the very high death-rate would not be equally divided among the natives and those who were not acclimated. Probably 120 in 1 000, or more, would represent the death-rate of those who were not acclimated.

The question then arises, Would it be possible to carry on work under such conditions, where 12 deaths occur in a year per 100 inhabitants, and many of them from tropical diseases like yellow fever, which causes the death of so large a proportion of those attacked by it and acts so quickly that a person taken sick one day may on the next be carried off to the cemetery? Would it be possible to get a sufficiently large force to remain on the work to complete the canal before those in authority reached the conclusion that the canal was costing too much in money and lives? What would be the nature of the organization, or, rather, of the disorganization under such conditions?

Dr. Coolidge has told us that there was a stampede from the work when yellow fever was prevalent on the Isthmus, at the time of Mr. Wallace's resignation. What would have been the result of the very much greater prevalence of yellow fever and of the very high death-rate which would have existed in the absence of sanitation? It seems obvious that there would be a continual change in the administrative force — the chief and other engineers dying or resigning as was the case at the time the French were actively engaged upon the work — and in other positions of responsibility, so that it would

be almost impossible to have a thoroughly effective organization. It is evidently not far from the truth to say that without sanitation it would not be possible to complete the canal.

The sanitary authorities succeeded in a comparatively short time in abolishing yellow fever and in maintaining conditions which resulted in a low death-rate for the whites. In the same time they also succeeded in reducing to a considerable extent the death-rate in Panama and among the black employees, but within the past year they have reduced to a greater extent the death-rate in Panama and have accomplished the wonderful result of reducing the death-rate among the black employees to about one third of that a year earlier, so that it is now as low as that of the whites.

I have already stated that the death-rate in Panama in the five years preceding the occupation of the Isthmus by the United States was 62. A reduction to 46 occurred in 1906 and to 34 in 1907, and the present rate is still lower. The death-rate of the black employees did not vary much from these figures until the latter part of 1907, when it began to diminish very rapidly, and the remarkable result of a death-rate for some recent months corresponding to less than ten annually has been achieved.

I think we can all appreciate the excellent work which has been done by Colonel Gorgas and his staff at the Isthmus, and that the greatest credit is due to them.

Chairman. — It may be of interest to the members to know that we have with us to-night the son of Colonel Goethals, who is studying at Harvard, and the son of Major Gaillard, who is studying at the Institute of Technology. They are with us to-night as guests. We have also with us one of the foremost health officers of New England, a man of whom you have all heard but whom, perhaps, you have never seen, — Dr. Chapin, of Providence. I will ask him to say a word.

Dr. C. V. Chapin. — I want to thank you very much for the privilege of being here to-night and hearing two men who have been on the ground tell about what has been done at Panama. I have heard men from Panama talk before,—one, Poultney Bigelow, for instance,— but that was another story. There has certainly been no disposition here to-night on the part of engineers to belittle the work of the physicians, and I can say, as I see these pictures and learn of the work being done there, that there is no disposition on the part of the health officer to belittle the work of the engineers. Frankly, it looks to me,

from these pictures, as though they had a mighty big job before them, and unless I had it on good authority I could hardly believe it possible that that canal could be dug within four years. I had the good fortune to serve as interne in Bellevue Hospital at the time Dr. Gorgas was there, and we were most excellent friends, and though we have unfortunately been separated by hundreds and thousands of miles since, I cannot help but take the greatest personal interest in his wonderful work at Havana and at Panama. It certainly seems true that this great work of building the canal could not have been accomplished without Dr. Gorgas' effort in preserving the health of the workmen on the Isthmus. At all events, if it could have been built without Dr. Gorgas and his work, it would only have been at an enormously increased cost. Yet I sometimes feel that the indirect results of Dr. Gorgas' work are even more valuable. You all remember that ten years ago we had faith that a general cleansing of any municipality would greatly improve the health of the inhabitants. You will remember that it was said that if we could clean Havana, yellow fever would be eradicated. Every one believed in what was called the filth theory of disease. The Americans went to Havana and they cleaned the city, as perhaps some of you know, so that it was cleaner than any city in the United States, and they had the worst epidemic of yellow fever the next year that they had had for many a day. That set them to thinking; Dr. Reed's commission began its studies and found what the real cause of yellow fever was, — that it was purely the contagion carried from one person to another by a mosquito. Then Dr. Gorgas went to work and killed the mosquitoes and stamped out yellow fever. That was the most brilliant sanitary achievement in history. I went to Havana on purpose to look into the work and see for myself what had been accomplished. We have heard a great deal about stamping out disease of one kind or another, but frequently, if one studies the facts at first hand, he will find that there is really very little stamping out. But of course we know there was no bluff in the work at Havana. What they did there really exterminated yellow fever and reduced malaria to a minimum. And what they did in the way of vaccination and the isolation of smallpox stamped out that disease which had prevailed there for years. The improved economic conditions resulting from American occupation of Cuba reduced the death-rate from tuberculosis. When in Havana I went to the health office and, together with Gorgas and Guiteras, studied

the vital statistics, and we soon saw, in examining those statistics, that it was in those diseases I have mentioned that remarkable decrease in the death-rate in Havana had chiefly taken place. The improvement was due to a definite attack on each one of those diseases, not to any general indefinite policy. Dr. Coolidge has told you what they have done in Panama; how they went to work and fought yellow fever in one way, tuberculosis in another, malaria in another, typhoid fever in another and pneumonia in another. There was no dependence on mere municipal cleansing. There was no indiscriminate attack upon disease in general — no "shotgun" policy. But they realized there, as was done in Havana, that the only way to carry on successful sanitary work is to acquire definite knowledge, apply it definitely, to take each disease in turn and apply appropriate methods to each. In that way one can get definite results and in no other way. And I believe after all that the share Colonel Gorgas has had in showing the value of such definite work will in the long run be worth as much as digging the canal.

CHAIRMAN JOHNSON. — The meeting is open for discussion. I have no doubt that Dr. Coolidge will be glad to answer any questions, and we shall be glad to hear from any one.

MR. R. S. WESTON. — Dr. Coolidge, may I ask one question? You spoke of administering prophylactic doses of quinine for malaria. After a while does that dose increase very much, or do you administer it intermittently, so the effect is not lost?

DR. COOLIDGE. — The object sought is to keep a certain amount of quinine in the circulation all the time. It is quickly eliminated from the body. A large dose of quinine taken to-day is largely eliminated in twenty-four hours. And it is just the people who are irregular in their prophylactic quinine who come down with malaria. I think the best dosage for prophylaxis was worked out by the Germans on the African west coast. It was found to be about 4 grains (0.25 gram) daily. Before we went to the Isthmus I had had malaria very severely. I had neglected it. On the Isthmus I made up my mind to follow Colonel Gorgas' advice and take my prophylactic dose, which I did — 3 or 4 grains, sometimes 6 grains after my coffee every morning. I never felt any effect from that dosage more than if I had taken another cup of coffee. The Americans on the Isthmus who won't take the trouble to take four grains a day conscientiously sooner or later find it to their advantage to

take anywhere from 30 to 60 grains a day, which I assure you is not an agreeable operation.

A MEMBER. — Did you ever use alcoholic stimulants in your work down there?

DR. COOLIDGE. — In the way of treatment of malaria. do you mean?

MEMBER. — Yes, or for general stimulant.

DR. COOLIDGE. — No, I think we never used alcoholic drinks in the treatment of any disease on the Isthmus, except occasionally, just as here in hospital cases, where the vitality is very low and alcohol is used as a temporary stimulant. It wasn't at all a part of the treatment of any of our diseases. In regard to the use of alcohol generally on the Isthmus, I think Americans have found that moderation in the use of stimulants on the Isthmus does them little or no harm; that excess on the Isthmus is worse than excess here, but that temperance on the Isthmus is as good as it is anywhere in the world.

[NOTE. — Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by September 15, 1909, for publication in a subsequent number of the JOURNAL.]

DISCUSSION BY J. P. SNOW OF PAPERS OF BOSTON SOCIETY OF CIVIL ENGINEERS, "WHY ENGINEERS DO NOT TAKE MORE PART IN GOVERNMENT."

(Volume XLII, Page 93, March, 1909.)

There are cogent reasons why some engineers should not enter the so-called political field. Many are salaried employees of the government, either municipal, state or national; and many more are railroad or other corporation employees. To run for elective office is taboo among officials of the national government, and it should be in a greater or less degree among salaried officers of all sorts.

Our honored past-president, McClintock, intimates that a railroad man may be a church treasurer, a trustee of an orphan asylum, a member of a board of health or even of a city council or board of aldermen. This is so because the duties of such positions are generally performed between two days or between two weeks. The paid-for duties of the class mentioned require their time during working hours, with perhaps an occasional jump-off of a few hours or a day or two. The Biblical mandate that a man cannot properly serve two masters still holds true, especially if he engages for full time with one. The ethics of the case prevent him from accepting service with outside interests that requires his thought and time to an extent deserving pay.

Engineers not in the salaried class are certainly free, so far as ethics are concerned, to accept or seek office; but, as hinted by the said far-seeing past-president, they cannot eat a stand-up lunch all by their lonesome and win.

Engineering is said to be an exact science. Winning a nomination to an elective office in the United States of America is not. Our wretched lack of system for making nominations, due to our daft ultra-democracy, precludes any one with a natural love of geometry, which is crystallized truth, from entering the lists. An engineer who finds geometry repugnant, as does the average law student, has missed his calling. Hence, to my mind, the scarcity of engineers, of the independent and consulting class, in the political field.

Every true citizen of this country believes that our system of government is the best on earth, but if he is fair-minded he will admit that there are rot-spots and sink-holes in our body politic that he greatly regrets. These blots I believe are wholly

due to our non-system of nominations. A nomination by the dominant party *is* the election. Who makes the nomination and hence elects the candidate? We have a strictly regulated and totally useless caucus, but the real nomination is not there. The actual nomination is made by a little clique of self-appointed men who will admit no dissenter to their conclave. They wield a mighty power, but they act without authority and are responsible to no one. If the nomination is bad no one can be held accountable, for there is no way to get hold of the parties who did the trick. To be sure, any dissatisfied voter can muster a few brother malcontents and make a counter nomination, but the result is simply another irresponsible clique with no more authority and perhaps no better morals than the first. The whole scheme is loose and bad; it breeds bosses by its very nature and there should be no wonder that engineers, who are true to the essence of their calling, decline to fraternize with it. When properly constituted public bodies, who can be held responsible for their mistakes, shall select the nominees for all parties, I think engineers will no longer shirk or shrink from accepting nominations, provided they are free to engage in public service.

As executives, engineers naturally excel; as law-makers, I have grave doubts of their capacity. For instance: The Boston Society of Civil Engineers has a system of nominating and electing officers; this is far better than the lack of system prevailing in our states and municipalities, for it always gives us good officers; but I think it the worst " system " that I have ever observed. The fact that, under it, the Society is well governed speaks volumes for the self-governing instincts of our members. The vagaries of our system, retained for so long a time, considered with the constitution-tinkering habit of the American Society, show what blockheads engineers are at law-making. The smooth working of both societies shows their superb executive and law-abiding possibilities.

DISCUSSION OF PAPER BY PROF. A. S. LANGSDORF, "ELECTROLYSIS OF REINFORCED CONCRETE."

(Vol. XLII, Page 69, February, 1909.)

Mr. A. A. Knudson. — It is no little satisfaction to the writer to find the results of others in experiments of corrosion of metals in concrete from electrolytic action, not only quite similar, but confirmatory of his early attempts in this direction.

Professor Langsdorf has employed a new and important feature in conducting such tests, viz., the determination of the loss in weight of the anodes as time went on as illustrated by the curve sheets. With these data the loss in weight of various structures may be computed with a fair degree of accuracy in a given time, if the current flow can be established, whether such are in concrete or soil.

The cause of cracking of the concrete blocks, which is mentioned, coincides with my own theory, viz., the enlargement of the anode, due to the deposit extracted from the metal, causes an outward pressure, which results in the bursting open of the blocks.

The following tests, made by the writer in the fall of 1907, seem to confirm this theory.

A concrete block $3\frac{1}{2}$ in. square by 12 in. long, with a hole 1 in. in diameter through its length, the bottom of the hole corked and paraffined, was placed in a glass jar nearly filled with water. A steel tube $\frac{1}{2}$ in. in diameter was placed in the hole and used as an anode with 0.1 ampere flowing for thirty days. The steel tube being much smaller than the hole in the concrete, it could be removed at times and examined. In this case there were no signs of cracks in the concrete, there being no opportunity for outward pressure; the deposit in the hole was in the form of a black thick paste when the test was concluded. The steel tube was badly pitted, the loss in weight being 42.0 gr. or 14.7 per cent., quite similar in appearance to Fig. 11, 2d series, in Professor Langsdorf's paper. We believe this test indicates that in the confined block the enlarging of the anode causes the cracks; in this later test, such condition being absent, there were no cracks.

This test also shows that electrolysis is just as active where the metal stands loosely, or separated from the concrete, where water is present as when it is tightly enclosed in same.

Professor Langsdorf calls attention to the necessity for great caution in the use of reinforced concrete structures, such as bridge abutments or concrete sewers, which may be in the vicinity of grounded railway circuits. To these I may add, *reinforced concrete standpipes* used for holding water; a recent examination of one by the writer disclosed a trolley current passing through the metallic parts, conveyed to same by the pipes. In this case, however, the flow at the time was practically eliminated by changes in the railway system.

This subject is as wide as it is important and the more light that can be thrown upon it by such investigations as Professor Langsdorf's the better.

DISCUSSION OF PAPER BY J. PICKERING PUTNAM, "SOME ANOMALIES IN MODERN PLUMBING REGULATIONS."

(VOLUME XLII, PAGE 157, APRIL, 1909.)

MR. A. B. RAYMOND. — As a member of the Detroit Engineering Society, I read with some interest the article on "Some Anomalies in Modern Plumbing." For eleven years, from 1897 to July, 1908, I served our Board of Health as their sanitary engineer, and from that experience have drawn some conclusions regarding our plumbing regulations which may be of some interest to those who are now discussing this subject.

First. Regarding the propriety of using the house-trap, I think that question should be left for each community to decide for itself. There are many situations where its use is desirable and many where it can well be dispensed with. Take it in our own city, in the new sections where all the drains and plumbing are constructed under regulation and inspection, it could be omitted with safety. Our regulations require it, however, at the present time. In other sections, where at times, in spite of all that is done to prevent it, crude oil escapes into the sewers from our manufacturing plants which use oil as a fuel, the house trap prevents a public nuisance.

Second. On the subject of back venting, the trend of present practice is to dispense with it whenever it can be done with safety, and rely upon the more economical method of the use of a good non-siphon trap.

Third. Sewer air is more of a nuisance than a menace to public health.

Fourth. The more we can simplify our plumbing construction with safety, the more general will become its use where it is now debarred on account of the expense. Place the possibility of having a modern closet and bath within the reach of all, and do away with the outside closet which is an offense, to say the least, in all of our cities.

OBITUARY.

Isaac Kingman Harris.

Member of Boston Society of Civil Engineers.

Isaac Kingman Harris, son of Isaac and Adeline Kingman Harris, was born in Grafton, Mass., February 15, 1840. His father was principal of the academy in that town. Owing to the death of his father, his early education was mostly obtained in the public schools of North Bridgewater, now Brockton, the home of his mother. He also attended Loomis Academy in the same town, where he prepared for Amherst College. After a year in college he concluded to follow the footsteps of his father and teach, and for that purpose attended the State Normal School at Bridgewater, graduating from there in 1862. He taught school for two years in North Bridgewater. Deciding to try civil engineering, he entered the office of Shedd & Edson, in Boston, in 1864. This firm was doing considerable work for the city of Lynn, commencing a sewerage system and establishing grades for its streets. Mr. Harris was engaged on this work. Later, the city, finding that the amount of work demanding the services of an engineer would warrant the employment of such a person continuously, the office of city engineer was established, and Mr. Harris was appointed the first city engineer of Lynn in 1870, a position which he held for six years. He afterwards established an office of his own in Lynn. In 1871 he married Miss Abby F. Lane, of Lynn, who survives him. He joined the Boston Society of Civil Engineers January 18, 1888.

Mr. Harris was quiet, conscientious and faithful. Honesty and integrity were marked characteristics of the man.

He identified himself with the various interests of the city, was a member of the Board of Trade, of the Historical and Horticultural Societies, was at one time a president of the Young Men's Christian Association, and for many years one of its directors. He joined the Central Church of Lynn and became the superintendent of its Sunday-school and one of its deacons, and served for many years as its treasurer.

One who knew him well says, " He preserved the even tenor of his way, and his life might seem an uneventful one; but, nevertheless, he has left a deep and lasting impression for good upon all with whom he came in contact."

It was the good fortune of the junior member of your committee to be intimately associated with him for sixteen years as assistant, partner and friend, and in all that time he never heard a single unkind word or an impatient expression pass the lips of Mr. Harris. Passion seemed to have no part in the makeup of Mr. Harris, but his sympathy was broad as heaven, and his constancy to duty could not have been greater. His influence upon the community in which he chose to labor during nearly forty years was not small, even if it was marked by no spectacular achievement. The men who have made this country great are the thousands who, each in his own community, have stood for truth and honor and charity and faith. Of such was Isaac K. Harris.

He died May 21, 1906, after about a year of lingering illness.

Otis F. Clapp,
Edwin F. Dwelley,
Committee.

William Albert Truesdell.

Honorary Member Civil Engineers' Society of St. Paul.

Died April 21, 1909.

William Albert Truesdell was born in New York City March 25, 1845. He was the fourth son of Verdine Truesdell, a steamboat owner and captain on the Hudson River, and Elizabeth Knapp. In 1851 the family moved to Wisconsin and finally settled on a farm at Wautoma.

After a high school course at Berlin he entered, at the age of eighteen, the University of Wisconsin, where he supplemented the general course by a special study of engineering, graduating in 1867. Then followed rather lean times for the young engineer. For a few winters he taught school. For a dozen years he was engaged off and on, here and there, principally in land and railroad surveying. He had then established a reputation as a locating engineer.

He married Miss Malvina N. Baker December 5, 1879. One son and two daughters survive him, Mrs. Truesdell having died about four years before his decease. In 1880 he entered the service of the St. Paul, Minneapolis & Manitoba Railway Company, and a considerable part of his work, probably a total of twenty years' service, on reconnoissance, location and con-

struction, has been for that corporation and its successor, the Great Northern Railway Company. All lines of construction, road bed, masonry and buildings received his attention.

While connected with the St. Paul City Engineers' Department in 1883–84, he designed and superintended the construction of the most important piece of masonry in the city, the twin skew arches which support Seventh Street over the St. Paul & Duluth Railroad. These arches, 124 ft. long, span 27 ft. and 37 ft.

His charge of the foundation of the Columbia River Bridge, built by the Great Northern Railway Company in 1895, sustained his reputation as an expert in this line of work. The construction of the general offices of the Northern Pacific Railway Company in 1896–97, and the erection of the Great Northern shops in St. Paul in 1902–03, were subject to his inspection. In 1897–98 he had charge of the Union Stock Yard Company's improvements in South St. Paul.

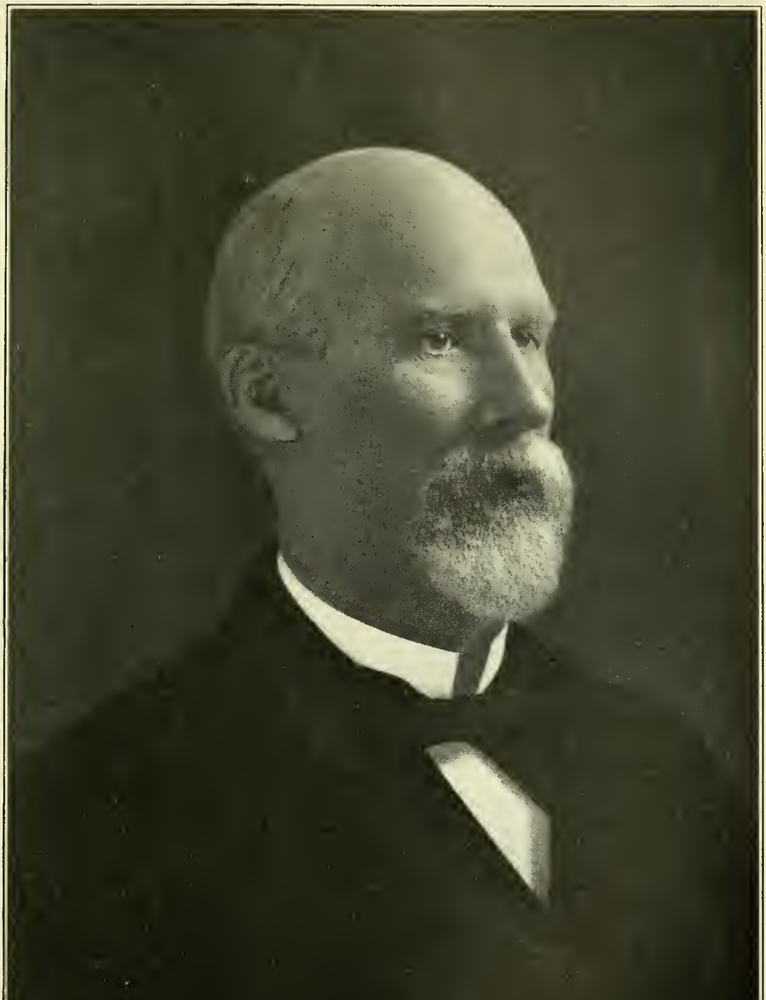
He does not appear to have been affiliated with many societies. The Hesperian Society, of Madison, Wis., was an early venture.

As a charter member of the Civil Engineers' Society of St. Paul, he contributed much to its success, in recognition of which he was advanced to honorary membership November 18, 1905. The following record tabulated from minutes of society meetings shows his continued interest in affairs of the society. The list gives subjects treated and dates of presentation:

"Building Materials," June 14, 1884; "Building Stone of Minnesota," April 6, 1885; "The Seventh Street Improvement Arches," October 5, 1885; "The First Engineer," March 4, 1895; "Work at the Union Stock Yards," February 7, 1899; "Life of Archibald Johnson," January 15, 1904; "Origin of System of United States Land Surveys," March 14, 1904; "The Rectangular System of Surveying," October 12, 1908.

Most of the above papers were published in the Journal of the Association of Engineering Societies. The *Wisconsin Engineer* published his paper on "Foundations" in October, 1896.

His recreation was in the study and investigation of such subjects as the history of the Constitution of the United States, the development of the science of mathematics, early western explorations, etc. His researches resulted in the getting of much information of special and lasting interest, which had long been hidden in volumes of matter of minor or temporary importance.



This he compiled in a complete and orderly manner. For fifteen years he delved for the substance of the paper on rectangular surveying.

His maps of the route to Astoria by the pioneers of 1810, together with explanatory manuscript notes, now repose in the library of the Minnesota Historical Society. There, too, were placed copies of his map and notes illustrating the Birch Coulie and Wood Lake affairs of the Sioux uprising in 1862.

The desire to go to the beginning of things and to clearly trace the development from first principles of subjects with which he was brought into contact led him to search among much dry matter for those pertinent facts which appear in his historical papers. It will be noted that it was his general practice to record the results of his experience and the outcome of his researches for the information of his associates.

Before going to the scene of his last assignment, in May, 1908, he attended a regular meeting of the Society bearing two valuable old books, the gems of his collection. In reminiscent mood he presented them to the Society. The evening was his. Such was the farewell, probably unanticipated. The following October he was forced to leave his work at Judith Gap, Mont., suffering from the effects of the high altitude, which induced an affection of the heart. He returned to his home in Minneapolis. In December he began to realize that the malady was serious, but he remained hopeful of recovery until almost the end, four months later.

His reputation for practical sense, thoroughness and accuracy was exceptional. Handicapped for many years by deafness, aggravated by exposure and advancing years, this bluff, undiplomatic, outspoken man of rigid standards seldom smiled, and yet he had a kindly manner, revealing a character which commanded respect, admiration and affection.

C. L. Annan,
A. H. Hogeland,
Alfred Jackson,
D. F. Jürgensen,
Committee.

Association of Engineering Societies.

Vol. XLII. JANUARY, 1909. No. 1.

PROCEEDINGS.

Engineers' Club of St. Louis.

St. Louis, January 6, 1909. — The 661st meeting of the Engineers' Club of St. Louis was held at the Club Rooms on Wednesday evening, January 6, 1909, at 8.30 o'clock, President Wall in the chair. There were present twenty-three members and five visitors.

The minutes of the 659th and 660th meetings of the Club were read and approved. The minutes of the 452d, 453d and 454th meetings of the Executive Committee were read.

The following were elected: W. H. Davis (associate member), E. A. C. Wahlers (associate member).

The following applications were presented: William H. Bixby (member), Ross M. Bristol (member), Michael O'Brien (member), William E. Rolfe (member), John F. Bratney (member), Morris C. Emanuel (member), James W. Skelly (member), Lewis B. Tebbets, 2d (junior member).

The paper of the evening on "Water Power Development in the West" was then presented by Mr. Otto Wiemer, of the Wagner Electric Manufacturing Company. Mr. Wiemer described, and illustrated by numerous lantern slides, different features of the plants of the Telluride Power Company of Utah, the Kern River plant of the Edison Company of Los Angeles, Cal., and of the Snoqualmie Falls plant in Washington, all of which had been recently visited by Mr. Wiemer. The slides showed the construction of the dams, flumes, penstocks, power houses and line construction of the various plants. At the conclusion of the paper the discussion was participated in by a number of those present.

Upon motion, duly seconded, it was unanimously voted to tender Mr. Wiemer the thanks of the Club for his courtesy in presenting the paper.

Adjourned.

A. S. Langsdorf, *Secretary.*

Boston Society of Civil Engineers.

Boston, January 13, 1909. — A special meeting of the Boston Society of Civil Engineers was held at Chipman Hall, Tremont Temple, at 8 o'clock p.m., Vice-President Francis W. Dean in the chair. One hundred and seventy-five members and visitors present.

Mr. Desmond FitzGerald gave a very interesting talk, illustrated by lantern slides, descriptive of the principal docks and harbors of Europe.

At the conclusion of Mr. FitzGerald's talk, a general discussion followed, after which the meeting adjourned.

S. E. Tinkham, *Secretary.*

Boston, January 27, 1909. — A regular meeting of the Boston Society of Civil Engineers was held at Chipman Hall, Tremont Temple, at 7.45 o'clock P.M., President Joseph R. Worcester in the chair. Seventy-nine members and visitors present.

The records of the last regular meeting and the special meeting of January 13, 1909, were read and approved.

Messrs. John F. Monaghan, Frank P. Morrill, David W. Stradling, James I. Tucker and Allen Van Rensselaer were elected members of the Society.

On motion of Mr. R. A. Hale, the President was requested to appoint a committee of three to report to the meeting the names of five members to serve as a committee to nominate officers for the ensuing year. The President appointed as that committee Messrs. R. A. Hale, E. P. Adams and H. B. Wood. This committee reported later in the meeting the following names for members of the nominating committee: E. W. Howe, R. S. Weston, A. G. Robbins, E. S. Larned and N. S. Brock.

On motion of Mr. Olin the report was accepted and the members named were chosen as the nominating committee.

Mr. Loud, for the Committee on Excursions, moved that the thanks of the Society be extended to the local officials of the General Electric Company for courtesies shown members of the Society this afternoon on the occasion of the visit to works of that company at Lynn, Mass. The motion was unanimously adopted.

Mr. A. W. Parker moved the following resolution:

Whereas, no full-size tests on large compression members have been made, there being no testing machine of sufficient magnitude for the purpose; and

Whereas, the necessity for such tests has been fully established and the results obtained from them would add greatly to engineering knowledge and be of material benefit to the industries of this country; and

Whereas, it is the sense of this meeting of the Boston Society of Civil Engineers that the building of a machine capable of testing to destruction full-size compression members of large dimensions and of accurately recording results is beyond the means of private interests and can best be undertaken by the United States government;

Resolved, that the United States government be hereby requested to make a sufficient appropriation for and proceed with the construction of a testing machine which will accomplish the desired results.

Resolved, that the Secretary be directed to forward copies of this resolution to the President of the United States, the Vice-President and the Speaker of the House of Representatives.

On a vote being taken, the resolutions were adopted unanimously.

In the absence of the author, the Secretary read the first paper of the evening, entitled "A Specification for Filing and Indexing Railroad Plans," by H. K. Higgins.

Mr. Alfred D. Flinn gave an abstract of the paper prepared by him, entitled, "The Filing and Indexing System of the Board of Water Supply

of New York City," and followed it with a very interesting account of the work of the Board, which was fully illustrated by lantern slides.

Mr. Herbert C. Hartwell read the third paper, entitled "The System of Indexing Plans used by the Boston Elevated Railway Company in the Department of Elevated and Subway Construction."

After a short discussion of the papers the Society adjourned.

S. E. TINKHAM, *Secretary.*

SANITARY SECTION.

A meeting of the Sanitary Section was held at the Boston City Club, on Wednesday, February 3, at 7.30 o'clock. Sixty-two members and guests were present. Mr. Harrison P. Eddy, chairman of the Committee on Collection and Tabulation of Sewerage Statistics, presented a progress report. On motion the report was ordered printed in the JOURNAL OF THE ASSOCIATION OF ENGINEERING SOCIETIES, together with the tabulation of sewerage statisties prepared by the committee.

Mr. Harrison P. Eddy then addressed the section upon the subject of "Day Labor *v.* the Contract System for doing Municipal Work." The talk was illustrated by diagrams and tables. The subject was discussed by several members.

ROBERT SPURR WESTON, *Clerk.*

Montana Society of Engineers.

TWENTY-SECOND ANNUAL MEETING, held at Great Falls, Mont., January 7, 8, 9, 1909.

THURSDAY.

This day was largely devoted to the preparation of various parts of the program work as outlined by the Committee of Arrangements, the same being composed of numerous members of the Society, residents of Great Falls. Considerable time was consumed in an attempt to secure suitable weather for the comfort of the out-of-town members, but not being successful in securing the desired concession, weather conditions were greatly neutralized by the cordiality, whole-souled hospitality and generous treatment provided instead for all the coming visitors. Cold days have very little to do with Great Falls hospitality.

FRIDAY.

As soon as possible after the arrival of the Butte and Helena members, in their special car, an engine was attached thereto and, under the guidance of Mr. Frank Scotten, all the members present became the guests of the Great Falls Water Power and Townsite Company, and proceeded to Rainbow Falls to view the construction work of the power dam there commenced. Mr. Scotten favored the members with a brief outline of the work under his supervision, and after an enjoyable season of inspection a visit was made to the company's engineers' quarters, and then to the boarding house, where a fine dinner awaited all, and its consumption drove away all dread of outside below-zero temperature. After a smoke and a

song the guests returned to their car and proceeded to the Great Falls smelter, there to be taken in charge by the officials of the B. & M. C. C. & S. M. Co. The great stack was approached by the trembling visitants, its tremendous dimensions and capacity calling forth mid frost and ice many exclamations from those whom the frosty air would permit to exclaim. Then a trip was taken through the several departments of the smelter, various operations witnessed and methods explained by courteous managers in charge. The afternoon passed rapidly and profitably. At the company's mess was supplied at an evening hour one of the most sumptuous repasts that ever came in the way of an hungry engineer. Besides the dinner, everybody was made the recipient of a magnificent copper souvenir, the gift of the B. & M. C. C. & S. M. Co., which, coupled with the superb programs received earlier in the day, crowned the real work of the trip. A pleasant evening at the Black Eagle Club permitted the discussion of the work witnessed, the renewal of acquaintances old and the forming of friendships new. Everybody gave little thought to the weather, shared in the songs and good fellowship everywhere so characteristic of the royal men who made such things possible. If any engineer thinks Friday's proceedings were a frost, he was not there.

Saturday.

The regular business session of the Society was called to order in the City Council Chamber, Cascade County Court House, at 10 A.M., President A. E. Wheeler in the chair, Twenty-two members present. Minutes of the last meeting read and approved. Applications for membership in the Society were read as follows: Herman C. Allen, Arthur Wellington Bower, Benjamin Clark Johnston, Charles Austin Lemmon, George William Weed. On motion, the applications were approved and the usual ballots ordered circulated. Messrs. Bow, Elliott, Jenks, Livers, Folsom, McAllister, Kuehner, Rowe, Crowfoot and Thill were elected to membership. The Secretary then presented the ballots of the officers elected. Tellers McArthur, Evensen and Shurick counted the same and reported 55 ballots cast, all "Yes." President Wheeler declared the officers elected for the year 1909, to wit: President, Charles H. Bowman; First Vice-President, Frank M. Smith; Second Vice-President, Fred W. C. Whyte; Secretary and Librarian, Clinton H. Moore; Treasurer and Member of the Board of Managers of the Association of Engineering Societies, Samuel Barker, Jr.; Trustee for three years, Theodore Simons. President Wheeler presented President-elect Bowman, who took the chair. The reports of the Secretary and Treasurer were read, approved and referred to the Trustees. The requests of George B. Couper and James M. Page for transfer to the Corresponding Membership Class were read and took the usual course. Several letters were read and the Secretary was instructed to reply to the same. A letter from Mr. G. F. Perrine regarding placing the county roads under the supervision of county surveyors elicited favorable discussion, and on motion it was voted that it was the sense of the meeting that legislation in this direction is necessary; that the matter be referred to the Board of Trustees for discussion and their conclusions conveyed to the proper legislative committee now in session. An interesting discussion regarding the change of the date of future annual meetings. also the

holding of mid-summer meetings, was had, and at length it was voted to refer the subject to the President, Secretary and Trustees to obtain an expression from the members. The Secretary announced the afternoon program and a recess was taken till 2 P.M.

The afternoon session was called to order by President Bowman at the hour designated. The Secretary presented the following applications for memberships in the Society: Alexander Gilfillen, William Lott Miller and Oscar Jerome Reynolds, which were approved and ballots ordered. The address of the retiring President, Archer E. Wheeler, was read by its author and received many complimentary remarks. A thesis by Mr. Joseph H. Harper, entitled, " Hydraulic Tables," was read by the Secretary, followed by another from Mr. Theron M. Ripley on the subject, " The New York Barge Canal." Mr. Ripley's paper was accompanied by a large map and numerous blue prints showing the route and methods of construction of that stupendous enterprise. At this juncture a lecture on the " Sun River Reclamation Project " was expected from Mr. S. B. Robbins, engineer in charge, but he reported the failure of the arrival of his lantern slides, and much to the disappoinment of the audience the subject was passed. A paper by Mr. F. W. Blackford was then read, entitled " High-Water Marks," and this concluded the literary part of the session. All the papers received the closest attention and high appreciation from every listener. The President called for a discussion on various topics along engineering lines, and much valuable information was brought out. The Secretary was instructed to express the acknowledgments of the Society to all who had helped to make the Twenty-Second Annual Meeting such an unqualified success, after which adjournment followed. The usual banquet followed in the evening, attended by much real enjoyment.

CLINTON H. MOORE, *Secretary.*

Technical Society of the Pacific Coast.

SAN FRANCISCO, JANUARY 16, 1909. — Regular annual meeting of the Technical Society held on January 16 at the Argonaut Hotel, where a banquet was tendered to Past President J. Richards, who intends to leave California in the near future for Europe, where he may remain for some years.

The guests assembled at the banquet table at seven o'clock P.M., where President George W. Dickie presided as chairman and toastmaster. The affair proved a most enjoyable one to all who attended, Mr. Richards responding gratefully to the courtesies extended to him and to his good wife.

The President delivered his annual address, referring to the past history of the Society and to the possibilities of its future, pointing out the useful work that may be rendered to the community in general by an organization of this kind.

A number of members took up the matter of the future activities of the Society and advanced their opinions as to the best manner and method by which the Technical Society and its work and standing in the community might be furthered and improved.

During the course of the evening the President appointed Mr. Franklin Riffle and Mr. Hubert Vischer tellers to open the ballots that had been mailed to the Secretary, containing a ticket of officers for the ensuing year.

The tellers reported that they had counted the ballots, and that the following ticket had been unanimously elected:

President — George W. Dickie.

Vice-President — H. D. Connick.

Secretary — Otto von Geldern.

Treasurer — E. T. Schild.

Directors — Hermann Barth, L. A. Hicks, Loren E. Hunt, Harry Larkin and Charles B. Wing.

The Secretary reported the general standing of the Society and submitted an annual report showing the number of members, which was not read, but ordered filed.

The Treasurer submitted the following report, which was not read but ordered spread on the minutes:

Report of the Treasurer of the Technical Society of the Pacific Coast for the Year 1908.

Oct., 1908.	Cash in bank		$750.67	
	Less checks unpaid		56.50	
				$694.17
	Cash received during the year			856.60
				$1 550.77
	Expended during the year 1908		$754.72	
	Cash on hand Dec. 31, 1908		2.20	
	Cash in bank Dec. 31, 1908	$814.85		
	Less one check unpaid	21.00		
			703.85	
				$1 550.77
	The receipts are as follows:			
	Cash in bank		$694.17	
	Dues collected		764.50	
	Two admissions		10.00	
	Dinner receipts		82.10	
				$1 550.77
	The expenditures are as follows:			
	Sundry expenditures, stamps, envelopes, and mailing		$59.45	
	Printing, typewriting, etc.		101.12	
	Salary of secretary		180.00	
	Collection and office help for accounts		26.00	
	Four assessments to Association of Engineering Societies		282.90	
	Mechanics Institute life members' dues		12.00	
	Expenditures for dinners		93.25	
				$754.72
	Cash in bank			703.85
	Cash on hand			2.20
				$1 550.77

Respectfully submitted,

E. T. Schild, *Treasurer.*

San Francisco, January 11, 1909.

The Secretary suggested that the regular committees be appointed from the recently elected directors, and that the President and Secretary continue to act on the Board of Managers of the Association of Engineering Societies as heretofore, until regular action is taken by the Directors of the Society.

The annual meeting thereupon adjourned.

Attest,

OTTO VON GELDERN, *Secretary.*

Utah Society of Engineers.

THE regular meeting of the Utah Society of Engineers was held Friday evening, January 15, in Salt Lake City. Two excellent papers were presented: one by Mr. Leonard Wilson on the subject of "Transformer Substations for Mining Districts," dealing with electricity, distribution to mines and smelters; also an interesting address from Prof. E. H. Buckstrand, of the State University, on the subject of "Results of Friction Tests on Some of the Lubricating Oils on the Market." Both papers were creditably presented and appreciatively discussed.

There were forty-one engineers present.

D. McNICOL, *Secretary.*

Association of Engineering Societies.

Vol. XLII. FEBRUARY, 1909. No. 2.

PROCEEDINGS.

Engineers' Club of St. Louis.

St. Louis, January 20, 1909. — The 662d meeting of the Engineers' Club of St. Louis was held at the Club rooms on Wednesday evening, January 20, 1909, at 8.30 o'clock, President Wall in the chair. There were present thirty-six members and fifteen visitors.

The minutes of the 661st meeting were read and approved. The minutes of the 455th meeting of the Executive Committee were read.

The following applications were presented: Charles M. Talbert (for membership); H. C. Burgess (transfer from junior to associate membership).

The following were elected: William H. Bixby (member); Ross M. Bristol (member); Michael O'Brien (member); William E. Rolfe (member); John F. Bratney (member); Morris C. Emanuel (member); James W. Skelly (member); Lewis B. Tebbetts, 2d (junior).

Prof. W. E. McCourt, of the Department of Geology of Washington University, made an exceedingly interesting address on "The Making of the Continent." He traced development of the land surfaces of North America, and particularly of the United States, from the earliest geologic period to the present time, illustrating his statements with a large number of lantern slides. At the conclusion of the address a considerable number of the members present asked questions about the subject, which were answered by Professor McCourt, and there was also some general discussion. It was unanimously voted to tender Professor McCourt a vote of thanks for his courtesy in addressing the Club.

Adjourned.

A. S. Langsdorf, *Secretary.*

St. Louis, February 3, 1909. — The 663d meeting of the Engineers' Club of St. Louis was held at the Club rooms on Wednesday evening, February 3, at 8.30 o'clock, President Wall in the chair. There were present forty-seven members and four visitors.

The minutes of the 662d meeting were read and approved; the minutes of the 456th meeting of the Executive Committee were read.

The following applications were presented: Richard L. Miller (for membership); J. A. W. Schoedel (for associate membership); John P. Materne (for associate membership).

The following were elected: Charles M. Talbert (member); Harold C. Burgess (associate member).

The President announced that a letter had been received on Monday afternoon, February 1, from the office of the State Highway Department that Mr. Curtis Hill had been taken ill and that he would be unable to keep his appointment to address the Club at this meeting on the subject that had been announced. The President announced that it had been arranged to substitute for Mr. Hill's paper one by Mr. A. S. Langsdorf on "The Fatigue of Insulation."

Mr. Langsdorf then presented informally an abstract of a series of experiments that had been made under his direction during the winter and spring of 1908, to determine the effects upon insulation of the rapidly reversing stresses due to an alternating difference of potential. The results of the experiments described showed that insulation exhibits the same fatigue phenomena that are found in the case of structural materials subjected to repeated loads, namely, that failure results from the repeated application of a stress which is less than that stress which will cause failure when gradually applied, provided that this reduced stress is above a certain critical value. It was also shown that failure in the case of insulation for a given applied voltage is directly proportional to the number of alternations of the stress. The tests described were made on three different kinds of insulating material, namely, empire cloth, pressboard and micanite, all of which materials showed the same phenomena, though in varying degrees. It was pointed out that the conclusions to be drawn from these experiments may have an important bearing upon the commercial specifications for the testing of the insulation of dynamo-electric machines.

The discussion which followed was participated in by a number of those present.

At the conclusion of the paper and the discussion, the meeting was adjourned to the adjoining rooms, where the Entertainment Committee had provided light refreshments and cigars.

Adjourned.

A. S. Langsdorf, *Secretary.*

St. Louis, February 17, 1909. — The 664th meeting of the Engineers' Club of St. Louis was held at the Club rooms on Wednesday evening, February 17, 1909, at 8.30 o'clock. In the absence of the President and Vice-President, Mr. Robert Moore acted as chairman. There were present thirty-two members and eleven visitors.

The minutes of the 663d meeting were read and approved. The minutes of the 457th and 458th meetings of the Executive Committee were read.

The following applications were presented: Robert P. Garrett (for membership); William J. Brown (for membership); Alfred C. Einstein (for membership).

The following were elected: Richard L. Miller (member); J. A. W. Schoedel (associate member).

Mr. Carl Gayler then presented the paper of the evening on "Bridge Designing." The author showed in an interesting way the development

of the box type of compression member and the rectangular section having multiple webs laced together, and pointed out the inherent weakness of this latter type, especially in the larger sizes, such as were used in the Quebec Bridge. A comparison of this type of member was made with the cylindrical compression members as exemplified in the arches of the Eads Bridge, and while it was shown that the latter is very much more expensive and more difficult to handle in the shops, it is very much more reliable in service. The author deplored the change in bridge building methods which has resulted in the standardization of design and construction to such an extent that the services of an engineer are of secondary importance, and he showed how this was directly responsible for the collapse of the Quebec Bridge.

The discussion which followed was participated in by Messrs. Fay, Toensfeldt, Russell and Moore.

Adjourned.

A. S. LANGSDORF, *Secretary.*

Civil Engineers' Society of St. Paul.

ST. PAUL, MINN., FEBRUARY 8, 1909. — The regular monthly meeting of the Civil Engineers' Society of St. Paul was held in the Society's room in the City Hall on Monday evening, February 8, 1909, President H. J. Bernier presiding. There were present fifteen members and sixty-six visitors.

Anticipating a large attendance, arrangements had been made for the use of the Grand Jury Room adjoining the Society's library for the evening.

The President introduced the speakers of the evening, Mr. W. H. L. McCourtie, secretary, and Mr. Geo. Dieckmann, chief chemist, of the Northwestern States Portland Cement Company, of Mason City, Ia., who addressed the meeting on the subject "A Modern Cement Plant" and the "Manufacture of Portland Cement."

The speakers traced the rock from the quarries, and the clay from the clay banks, through all their different processes of manufacture, the drying, crushing, burning, mixing, etc., to the finished product in the sack ready for use. The lectures were very profusely illustrated with stereopticon views and were very interesting as well as instructive, which was made manifest by the appreciation expressed by all present.

At the conclusion of the addresses the members retired to the Society's room to dispose of such business as might regularly come before them.

It was moved and seconded that "the reading of the minutes of the previous meeting" be dispensed with.

On motion duly seconded it was voted to allow the customary $10.00 for the caretaker of the Society's room, and the Secretary was ordered to draw an order on the Treasurer for the same.

The following applications for membership were presented: Edw. C. Hollidge (member); Peter A. McLeod (junior member).

It was moved and seconded that a written ballot be cast for each applicant separately, which was done, and both applicants as above mentioned were duly elected unanimously.

It was moved and seconded that the Society pass a vote of thanks to Mr. W. H. L. McCourtie and Mr. Geo. Dieckmann for their interesting addresses of the evening.

Mr. D. F. Jurgensen presented to the Society for its library, on behalf of the Minnesota State Railroad and Warehouse Commission, five copies of the Commission's Valuation Report of the Minnesota Railroads, which valuations had been prepared for them by Mr. Dwight C. Morgan.

Mr. H. J. Bernier presented to the Society a large photograph of the banquet group at the annual meeting of January 11, 1909.

A discussion followed in which the inadequacy of our present quarters, which had made itself manifest by the large attendance of the evening, was the main subject, and it was finally moved, seconded and voted that Mr. Oscar Palmer and the Secretary investigate and ascertain what could be done towards procuring a suitable room in which to hold our open meetings and lectures, they to report to the government of the Society before the next regular meeting of the Society.

There being no further business the meeting was adjourned.

D. F. Jurgensen, *Secretary.*

Louisiana Engineering Society.

January 6, 1909.

To the Board of Direction, Louisiana Engineering Society:

Gentlemen, — As Secretary of the Society, I beg to submit the following report for the year 1908:

During the year there were twelve regular and one special meetings. Five of these were held in Gibson Hall, Tulane University, seven in the Special Committee Rooms of the Hibernia Building, and one, the annual meeting, in the Hotel Denechaud.

The total attendance for the twelve regular meetings, including guests, was 413, or an average per meeting of 34. The smallest attendance was 15 on September 14, and the largest was 85 on November 9.

The membership roll for the year changed as follows:

	Member.		Asso. Mem.		Junior Mem.		
	Res.	Non-R.	Res.	Non-R.	Res.	Non-R.	Total.
As per report, Jan. 11, 1908,	76	13	5	..	12	...	106
Elected since	25	8	1	1	2	1	38
Reinstated	4	..	..	..	..	...	4
Total	105	21	6	1	14	1	148
Forfeited membership	5	..	..	..	...	...	5
Forfeited election	1	..	..	1	...	...	2
Resigned	2	..	1	..	1	...	4
Died	1	..	1	..	...	...	2
Net	96	21	4	..	13	1	135
Transfers	+6	—1	...	..	—5	...	...
	—2	+2	...	..	—1	+1	...
On roll, Jan. 6, 1909	100	22	4	..	7	2	135
Net gain	24	9	1	..	5	2	29

Submitted separately is a financial report which is attached to, and made part of, this report. It shows a balance on hand, January 1, 1909, of $193.22. Open accounts for dues and keys amount to $150.25, of which $16.25 have been canceled owing to death of two members, $69.50 have been forfeited, leaving $64.50 collectable.

The following exercises were held during the year:

January 11. — Address of retiring President, G. W. Lawes.

February 10. — Outline of Work of Model City, by Advisory Committee.

March 9. — Report of Sub-Committee on Site of Model City, by G. W. Lawes.

April 13. — Report of Sub-Committee on Levees and Surface Drainage," by Major F. M. Kerr, read by Major B. M. Harrod.

May 11. — Four competitive plans of Model City were submitted by various groups of members of the Society.

June 8. — Discussion of plans of Model City by members of Society.

July 13. — Paper read by Major F. M. Kerr, on "Closing of Beka Crevasse." Published.

August 10. Report of Advisory Committee on Competitive Plans of Model City submitted, accompanied by a fifth map of Model City as designed by the committee.

September 14. — Report of work accomplished by the committee on future New Orleans.

October 12. — Progress report of the Future New Orleans Committee, and a talk on "Some Submarine Surgical Operations," by C. W. Wood.

November 9. — Paper read by Major B. M. Harrod on "Caving Banks," and discussion by members.

December 14. — Paper read by Mr. John Klorer on the "Water Hyacinth Problem."

The last two were ordered published.

During the year the Society completed the design of a Model City on the site now occupied by New Orleans, and is now engaged in the design of Future New Orleans.

The Needham Bill, providing for the continuation of investigations of rivers and water resources of the United States, was endorsed by the Society.

The McKinley Bill relative to the establishment of engineering experimental stations at various A. and M. colleges was endorsed on first reading only, owing to lack of copy of bill.

The Society was instrumental in the passage of Act 308, Regulating the Practice of Civil Engineering and Surveying in Louisiana.

The Society amended Article 3, Section 3, of the constitution relative to Board of Direction filling vacancies in the lists of officers, until such time as a letter ballot is taken.

Article 4, relative to the nomination of officers, and part of Article 6, relative to charging dues of newly elected members beginning with the quarter in which they enter, were also amended.

The Society moved its headquarters and library from Tulane University to Hibernia Building, owing to the practical inaccessibility of the library during the day. Keys were distributed to all members in New Orleans, and to some non-resident members.

New constitutions and lists of members were printed about May 1.

A badge of membership was adopted and is now being worn by members.

The Society recently decided to act as a medium to collect $200 from individual members to be loaned to the State Board of Engineering Examiners.

Affiliations in exchange of house and library privileges were entered into with some ten engineering societies in different parts of the country, making a total of 18 in all.

The Secretary wishes to thank the members of the Board of Direction for their loyal coöperation in the work attached to his office, and especially to President Wood for the great amount of valuable assistance rendered by him throughout the year.

Respectfully,

L. C. Datz, *Secretary.*

January 9, 1909.

To the Louisiana Engineering Society:

Gentlemen, — Your Board of Direction begs to report that during the year 1908 it has held 12 regular and 13 special meetings for the transaction of the Society's business.

Attached are the reports of the Secretary, Treasurer, Auditing Committee, Library Committee, Membership Committee, Future New Orleans Committee and Bureau of Information Committee, showing in detail the work accomplished.

The financial report of the Secretary will show a comfortable balance of $193.22 with which to begin the new year. Increased expenses in printing, rent, salary, periodicals, petty cash, in fact, in almost every account, together with expenses incidental to the passage of Act 308, to the Model City Design and to buying new furniture and books, are reasons for this smaller balance than last year.

The Secretary's report will also show a net gain of 29 men for the year, and a net enrollment of 135.

The Treasurer's report will show receipts for the year, including last year's balance, to be $2 172.22, and expenses, $1 979.

Upon the earnest solicitation of some members, the board undertook to get the signed opinions of members in New Orleans relative to again moving in the business district. These opinions were submitted to the Society, and then decision to move resulted.

Acting upon advice of the last Board of Direction, new constitutions and lists of members were printed about May 1, and several changes in the constitution were recommended to and adopted by the Society.

Upon instructions from the Society, the board recently established a Bureau of Information to assist engineers looking for men to employ, and men looking for engineering positions.

Upon authority given by the Society, the Board suggested 10 names to the governor of Louisiana, from which he has selected 5 to constitute the State Board of Engineering Examiners.

The Board of Direction would recommend the following:

The creating of honorary members to the Society Roll.

The complete cataloging and indexing of the library if practicable.

The printing of revised pages for existing constitutions.

The purchase of a suitable filing cabinet for letters and papers of the Society.

Respectfully submitted,

THE BOARD OF DIRECTION.
C. W. WOOD, *President.*
L. C. DATZ, *Secretary.*

ASSOCIATION
OF
ENGINEERING SOCIETIES.

VOL. XLII. MARCH, 1909. No. 3.

PROCEEDINGS.

Boston Society of Engineers.

BOSTON, FEBRUARY 17, 1909. — A regular meeting of the Boston Society of Civil Engineers was held at Chipman Hall, Tremont Temple, at 7.45 o'clock P.M., President Joseph R. Worcester in the chair. Fifty-two members and visitors present.

The record of the last regular meeting was read and approved.

Messrs. Fred R. Charnock, Edward A. Haskell, Frank A. Marston and Ralph I. McCorkindale were elected members of the Society.

Mr. Cowles, for the Committee on Larger Membership and Club House, submitted and read a report from that committee. On motion of Mr. French it was voted to accept the report and to print it in the next issue of the Bulletin. It was also voted to continue the committee.

On motion of Mr. Howe, the President was requested to appoint a committee of such a number as he deemed best, to coöperate with the committee of local members of the American Society of Civil Engineers on arrangement for the annual convention of that society, to be held at Bretton Woods, N. H., in July next.

The Secretary announced the death of Timothy Guiney, a member of the Society, which occurred February 4, 1909, and by vote the President was requested to appoint a committee to prepare a memoir. The President has appointed as members of the committee John N. Ferguson and John L. Howard.

The Secretary read the following amendments to the Constitution and By-Laws which had been submitted in writing:

Amend Article II of the Constitution by the addition of the following paragraph, to follow the third paragraph as it now stands:

" Members in good standing who have retained their membership for thirty years may, by relinquishing their right to receive notices and publications of the Society, be relieved of further payment of fees, dues and assessments and still be retained on the roll of the Society as retired members."

Amend Section 7 of the By-Laws by adding thereto the following paragraph:

" Transfer of members to the Retired list shall be made only by vote of the Board of Government."

The President called Mr. A. H. French to the chair, who introduced Mr. Henry M. Haven, member of the American Society of Mechanical

Engineers, who read a very carefully prepared paper entitled "Mechanical Refrigeration and Some of its Modern Applications." The paper was fully illustrated by lantern slides.

After a short discussion, on motion of Mr. Howe, the thanks of the Society were tendered Mr. Haven for his very interesting paper.

Adjourned.

S. E. Tinkham, *Secretary.*

Report of Committee on Larger Membership and Club House.

Boston, February 17, 1909.

To the Members of the Boston Society of Civil Engineers:

At the regular meeting of the Society held on November 18, 1908, the following motion was passed:

Voted: "That the Committee on Larger Membership and Club House be continued and instructed that it is the earnest desire of the Society to acquire a permanent home or club house at the earliest feasible time: that the Society desires the committee to confer with the New England Water Works Association, the Architectural Societies, the Gas Engineers, the Railway and Railroad Clubs and any other association which may be suggested or which, in their opinion, might be desirable to have coöperate with this Society in securing a suitable building; that the committee carefully investigate the question of financing a building or club house and report at length as soon as possible."

In accordance with these instructions your committee has given further consideration to the question of a suitable club house or home for this Society. Four general propositions have been studied in some detail.

(1) A club house without *cuisine*, to be used exclusively by the Boston Society of Civil Engineers.

(2) A commercial (ten-story) building with the several engineering and architectural societies occupying the upper floors (a plan similar to the "Broad Street" scheme as worked up by a former committee).

(3) A union club house without *cuisine*, for the exclusive use of the several engineering and architectural societies whose headquarters are in Boston.

(4) A "technical club house," combining all the features of a first-class club, with suitable smoking, dining and perhaps sleeping rooms, the several engineering and architectural societies to rent quarters in the building, but the membership of the club proper to be separate from the other societies.

In any of these schemes there are a few main questions that bear closely on the success of the enterprise. These concern the finances (including maintenance), location, sociability, accommodation for meetings, library (both as regards space and protection from fire), expansion and possibility of using building for other purposes in case necessity arises.

Scheme 1. A club house for the exclusive use of the Boston Society of Civil Engineers no doubt appeals strongly to most of the members, and rightly so. The cost of a site in such location as would prove acceptable to the majority of the members would not be less than \$50 000. Add to this some \$25 000 for a three-story building with auditorium in the basement, fireproof in order to properly protect our valuable library, and the

burden imposed, especially that of maintenance, would surely be greater than the present finances seem to warrant. A *cuisine* in connection with this proposition would not be self-supporting.

SCHEME 2. The erection of a ten-story building to be used partly for offices, the balance to be given up to the various engineering and architectural societies, would no doubt be feasible from a financial standpoint, but such an undertaking must necessarily be handled by an expert, and it is the opinion of your committee that it would be preferable for the different societies to congregate in some existing building than for this Society to assume the responsibility of financing a new enterprise along these lines.

SCHEME 3. Your committee has received unofficial assurance that the Water Works Association and the Gas Engineers are willing to occupy new quarters with this Society on substantially the same basis as at present. Similar information shows that the Boston Society of Architects and the Boston Architectural Club would be willing to occupy quarters in a new building as joint tenants with the engineering societies. No conference has been held with officials of the Boston Section of the American Institute of Electrical Engineers, as the Board of Government has appointed a committee for this purpose. Any union building must be centrally located and contain an auditorium capable of seating at least two hundred persons. The installation of a *cuisine* is not advocated.

Before any definite information can be obtained respecting the support which the societies above referred to will be willing to give to this scheme, some location must be found and some general plan of building proposed, with an estimate of the probable cost of construction and maintenance.

There is at the present time one piece of property on Beacon Hill for sale, centrally located and suitable for a union building site. The cost of site together with a new building would represent an outlay of at least $80 000. The minimum annual operating expenses for such a proposition are estimated as follows:

$80 000 @ 4 per cent.	$3 200 00
Heat, light, water and insurance	1 000 00
Janitor service and care	1 000 00
Taxes (at $16.25)	1 300 00
Repairs and incidentals	500 00
Total	$7 000 00

(Nothing is here allowed for sinking fund.)

The rent paid by the Society and its sub-tenants for the present quarters is approximately $2 000 per annum. With a slight readjustment of our dues, making the maximum dues $10 instead of $8 as at present, about $1 000 might be added to the present income of the Society (allowing for a reasonable number of resignations on account of such increase). The balance required, $4 000, must be raised by rentals paid by the other societies.

SCHEME 4. A brief study of the local engineering and architectural professions indicates that there are probably five thousand men employed in these professions within a radius of 15 miles of Boston. It occurred to your committee, therefore, that with this large number from which to

draw, a Technical Club might be formed, the membership being composed of engineers, architects, members of allied professions and perhaps others associated in a business way with these professions; this technical club to purchase land and erect a suitable building for the accommodation of the Boston Society of Civil Engineers and other engineering or architectural associations. These associations would lease from the Technical Club that particular portion of the building which each is to occupy exclusively, and pay a fixed rental for such space. Suitable auditoriums would be provided for the use of the societies. The remainder of the building could be laid out as a first-class club house, with a kitchen and dining-room, a common smoking-room, small conference rooms, billiard and pool room and possibly some sleeping rooms. The privileges of the club house portion of the building would be open to all members of the societies who are also members of the Technical Club and to members of the Technical Club who may not be members of any individual society.

While numbers are necessary for the success of such an enterprise, the question of securing the sympathy and support of the influential men in the profession is of paramount importance.

The keynote of any change that is to be made in the present quarters, condition and general atmosphere of this Society ought to be the question of sociability. The immediate success of the City Club here in Boston is conclusive evidence of the fact that there is an increasing demand for a club with moderate dues which is at all times inclusive rather than exclusive.

At the annual meeting it is hoped that the views of a majority of our members may be obtained on this important matter. In case any of the above propositions is cordially received, a further study of the subject may then be made and a detailed investigation instituted.

Respectfully submitted,

Luzerne S. Cowles,
Charles B. Breed,
George A. Carpenter,
Ralph E. Curtis,
Edward S. Larned,
Committee.

Sanitary Section.

The annual meeting of the Sanitary Section of the Boston Society of Civil Engineers was held at the Boston City Club, on March 3, at 7.30 o'clock. Reports of the committees on "The Run-off from Sewered Areas," "The Manufacture of Sewer Pipe," and "The Collection and Tabulation of Sewerage Statistics" respectively, were read and placed on file. The report of the Executive Committee was read and showed a membership of 173, including 20 who are not members of the Boston Society of Civil Engineers.

The following officers were elected for the coming year: Chairman, Frank A. Barbour; Vice-Chairman, Bertram Brewer; Clerk, Robert Spurr Weston; additional members of the Executive Committee, William S. Johnson, George A. Carpenter, Alexis H. French.

Arthur Fuller Harkness was elected a member.

William S. Johnson presented a paper entitled, "The Volume of Sewage in Sewers Designed according to the Separate System." Several members took part in the discussion. Fifty-one members and guests were present.

Robert Spurr Weston, *Clerk.*

Boston, March 17, 1909. — The annual meeting of the Boston Society of Civil Engineers was held at the Boston City Club, 9 Beacon Street, at 11 o'clock A.M., President Joseph R. Worcester in the chair. About one hundred and fifty members and visitors present.

The record of the last regular meeting was read and approved.

The President announced that in compliance with the vote passed at the last meeting he had appointed Messrs. George B. Francis, Leonard Metcalf and Dexter Brackett a committee to coöperate with the local members of the American Society of Civil Engineers on arrangements for the annual convention of that society, to be held at Bretton Woods, N. H., in July next.

The President also announced that he had appointed Messrs. George H. Brazer and Wilbur W. Davis as tellers to canvass the ballots for officers for the ensuing year.

Messrs. Clayton R. Elkins, Herman W. French, Arnold W. Heath, Dugald C. Jackson, Granville Johnson, Lewis E. Moore and Ernest C. Willard were elected members of the Society.

The Secretary read his annual report and, on motion, it was accepted and placed on file.

The President read the annual report of the Board of Government and, on motion, it was accepted and placed on file.

The Treasurer read his annual report and, on motion, it was accepted and placed on file.

Mr. Loud, for the Committee on Excursions, presented and read its annual report, which was accepted and placed on file.

The Librarian read the annual report of the Committee on the Library and, on motion, it was accepted and placed on file.

Mr. FitzGerald made a verbal report for the Committee on Quarters.

Mr. Cowles, for the Committee on Larger Membership and Club House, submitted a report on the establishment of a bureau of registration and a broader and more specific classification of membership. The report was accepted and placed on file.

On motion of Mr. Curtis it was voted to refer to the Board of Government with full powers the question of appointing the special committees of the Society and the selection of the members thereof.

It was voted to appropriate the sum of $50 for the purchase of new reference and text-books during the coming year.

On motion of Mr. Sherman, the matter of providing assistance for the Secretary, as suggested in the annual report of the Board of Government, was referred to that board with full powers. It was further voted, on motion of Mr. FitzGerald, that it was the sense of this meeting that it would be a wise thing to provide some assistance to the Secretary.

The recommendations and suggestions of the Committee on Larger Membership and Club House were referred to the Board of Government with full powers.

The consideration of the report of the Committee on Larger Membership and Club House, submitted at the February meeting, was then taken up.

After a full discussion it was finally voted, on motion of Mr. Johnson, that it is the sense of this meeting that the Society should adopt some plan of procedure similar to that of the committee's Scheme 3. The vote was 48 Yes and 9 No.

On motion of Mr. Bryant, it was voted: That the Board of Government and the Committee on Quarters, with the special Committee on Larger Membership and Club House, be requested to definitely formulate a plan along the lines of Scheme 3, and that the Board of Government be authorized to expend such funds to that end as may be required, it being understood that the cost of the proposed scheme should not exceed $125 000 including land and building.

At the request of the President, Professor Hollis, chairman of the committee appointed by the Board of Government to consider the formation of a Mechanical Engineers' section, reported informally what the committee had done and stated that a report would soon be submitted to the Board of Government.

The consideration of the following amendments to the Constitution and By-Laws presented at the last meeting was then taken up.

Amend Article II of the Constitution by the addition of the following paragraph to follow the third paragraph as it now stands:

"Members in good standing who have retained their membership for thirty years may, by relinquishing their right to receive notices and publications of the Society, be relieved from further payment of fees, dues and assessments and still be retained on the roll of the Society as retired members."

Amend Section 7 of the By-Laws by adding thereto the following paragraph:

"Transfer of members to the retired list shall be made only by vote of the Board of Government."

After a discussion of the proposed amendment to the Constitution, on a vote being taken it was not adopted.

Consideration of the amendment to the By-Laws was then taken up.

Mr. Howe moved to amend the proposed amendment by substituting the following:

"The Board of Government may for such reasons as it may deem sufficient remit the dues in any current year of any member whom it may find to be unable to pay the same, no record to be made of the name of such member."

On a vote being taken the substitute was adopted.

A vote was then taken on amending the By-Laws by the addition of the proposed paragraph and it was carried unanimously.

President Worcester then delivered the following address:

At the close of a year's service in this honorable position, it is fitting that the incumbent should take the Society into his confidence and give it the benefit of what he has gained by his experience.

It is perhaps inevitable that one's feelings should be tinctured with a shade of disappointment. At any rate, that is the case in the present instance. It is natural for us to fall short of attaining our ideals and to have many regrets for failure to accomplish what we may have dreamed of. On this account it would be perhaps better if the President had a

chance to make his annual remarks earlier in his career, — as in the case of the American Society of Civil Engineers, while his hopes and aspirations are in their prime, and he has not yet reason to doubt of his power to fulfill them. In that case he would be spared the humiliation of confessing failures, and the character of his remarks would no doubt be more optimistic. On the other hand, if the President is learning, as he should be throughout his year of office, his advice, to be good for anything, ought to be invoked after rather than before he has been through the mill.

Then, again, while there have been disappointments, there have also been many satisfactions, and the tone of this confession should not be too dismal. The failures of one president can possibly be turned to some advantage if they lead to the avoidance of pitfalls by his successor.

Taking a general view of the status of the Society, it seems as if we had reached a turning point in our career. Looking back over our history, it would seem as if we were on the eve of a third chapter. The first chapter began sixty years ago and was of comparatively short duration, for the Society maintained meetings for a few years only. The second chapter began in 1874 with the formation of the "New Society which was merged with the original one after the members learned of its innocuous existence. The second chapter has been vastly more successful than the first, but it seems to the speaker as if it had been subject, to some extent, to the same disease which put the first one out of commission, and which may require heroic treatment to extirpate unless taken in time. This disease is one very prevalent in organizations of this character. It is sometimes wrongly called dry-rot. It is certainly not that with us. It is an organic disorder of the reproductive functions.

For the perpetuation of the life of any society it is not only essential for new blood to be acquired fast enough to replace that of the men whose active interest flags, but for the control and management of the society to be in the hands of those whose interest is fresh. That this is not the case with us may be seen from the following statistics. Taking the officers of the Society for the last ten years, it appears that the average time that the presidents had been members of the Society at the time of their election was 23.1 years. The corresponding periods in the case of the other officers was as follows:

Vice-Presidents......	16.6 years.	Librarians...........	9.9 years.
Secretaries	25 years.	Directors............	11.1 years.
Treasurers..........	24.5 years.		

This makes the average length of connection with the Society of the Board of Government between seventeen and eighteen years.

Is it according to human nature that men who joined the Society at about the time the new members were donning their first trousers can so direct the Society as to make it attractive to the newcomers? This was not so at the beginning of the chapter. Then the officers were contemporaries of all the members. This condition, in the nature of things, could not long continue, but there can be no doubt that as the disparity in ages between the officers and the new members increases there is grave danger of a lack of sympathy, which is of vital importance.

The speaker would be the last to reflect upon the value to the Society of the older members. The faithful attendance at the regular meetings of a few whose connection with us has lasted more than a third of a century is an inspiration to the younger members and an example of no little importance. Neither would we belittle the fact that but for the labor of love of some of our older officers it is hard to see how the Society could have continued to exist. At the same time it is probably true that it is during the first ten years of an engineer's connection with the Society that he is most apt to need its help and to be able to avail himself of it, and it is to those newer members that our meetings should be generally adapted. Can this be successfully accomplished without giving to the newer members a larger representation on the Board of Government?

Evidences of the restiveness of the younger element have been frequent during the past year. Some signs have appeared in the meetings of the Society, but more have been disclosed by the private conversation

with members which is a president's privilege. This restiveness indicates a transition period, and its results will be awaited with interest. The advice engendered by this experience is to adjust ourselves to the conditions, to give the younger element a show and to let them have their way whether it seems to our superior wisdom best or not.

The responsibility for the selection of officers should not be laid at the door of the older members alone. Our method of choosing officers would seem to give all an equal chance, and by taking a proper interest in the affairs of the Society the younger element would be much more likely to find places on the Board of Government, but, nevertheless, with our rules, it is nearly hopeless. The intention of the by-law with regard to the election of officers is to give a wide choice, and to remove any suspicion of political jobbery in the selection of candidates. No doubt it has accomplished this result, but its success has been attended with some disadvantages. The nomination of three candidates for every position, besides bringing the unpleasant sense of defeat to two-thirds of the men voted for each year, has the effect of inevitably forcing the membership to make a choice between men of widely differing terms of service in the Society. The letter ballot does the rest of the evil. Those who vote, in a very large proportion, are men who seldom, if ever, attend the meetings. They do not know the younger members. In the list of candidates they are likely to find one whom they may know, or, at least, know by reputation, and they are pretty sure to vote for him. He may be the best man for the position, but he is more likely to be one whose professional advancement has made such demands upon his time that he has lost touch with the Society, and, in taking it up at a personal sacrifice, cannot readily acquire the spirit of the younger element. In many organizations there may be great danger in allowing those in control to have any part in the selection of their successors, but in our Society it is open to question whether the officers do not know better who should follow them than the membership at large. This may be going to the other extreme, and probably no such method of selection would be tolerated. It would be well to consider, however, whether it would not be wise to leave it to the discretion of the Nominating Committee how many names should be submitted for each office, but requiring them to include in the list names presented to them in writing by (say) any twenty-five members of the Society. The letter ballot with more carefully selected nominees would be robbed of its evils.

The most disappointing circumstance connected with the past year has been the failure to render the meetings attractive to the bulk of our membership. The character of the papers presented has been high, and the programs have been varied and comprehensive, but the attendance has often been a dismal failure. The speaker regrets that he has sought in vain for the explanation of this, and must turn the problem unsolved over to better hands. It appears from the attendance that it is not stereopticon illustrations nor is it instructive technical papers that the Society wants so much as descriptive accounts of work of general interest. We cannot doubt that the members value highly the technical papers, but they probably count upon being able to read them in print at their convenience and with leisure to digest them. This temptation is a strong one, and the speaker must plead guilty to having yielded to it frequently in the past. A year in the President's chair has the good effect of showing the incumbent his duty in this respect, for the attendance of past presidents is very creditable. Each member should realize that it is of much importance, not only to himself, but to the Society as a whole, that he should hear the papers read at the meetings. Then only will he have a chance to ask questions of the author, and with our present method of publication discussion of subjects open to controversy or even demanding statements in reply is likely to be overlooked.

As an example of the danger of this lack of discussion the Society has been severely criticised during the past year. In the fall of 1907 a paper was presented by an engineer interested in a certain system of waterproofing. The attendance at the meeting when the paper was presented was not large and did not include those who were prepared to answer the author and present the arguments on the other side. Several months later the paper appeared in the Journal, with the usual invitation to

readers to present discussions. Those of the members who read it either felt that the subject was cold and that the time had gone by to take it up, or lacked the interest and inclination to take up cudgels. As a result it looked to the engineering profession as if the Boston Society accepted without remonstrance the statements made in the paper. Unless the members of the Society will fully discuss subjects presented, it looks as if the Board of Government must review all papers presented and make sure that they contain no heresy before allowing them to be read. This would be a deplorable result. In the speaker's judgment one of the chief duties of the Society is to bring out one-sided opinions and to offer a forum for their discussion. The concensus of testimony should be sane and safe.

A very valuable aid to producing a discussion would be the distribution of the papers in print before their presentation at the meetings. This, it may be confessed, was one of the speaker's plans which he has absolutely failed to accomplish. It would be possible to do this by means of the *Bulletin*, at a minimum of expense, by arrangement with the Association of Engineering Societies. The papers could be put in type in advance by the press which publishes the JOURNAL, and electrotype plates could be prepared at a small cost, which could be used in the preparation of the *Bulletin*. The additional cost would be little more than the extra paper and sometimes postage, and these should be offset by the increase in advertising value. The trouble is that it seems almost impossible to secure the copy of the papers in advance of the meetings. In fact, it is often hard enough to get it for months after presentation. The coöperation of all members is essential for the success of this project.

The offering of papers by members is not as free as it should be. It ought not to be necessary for the officers to solicit papers, but they should be voluntarily tendered. Americans might well learn a lesson from our European friends in this respect. There it seems to be the regular custom for engineers to lay before the public their accomplished works as well as the results of their researches, and this is the true professional spirit. Here, on the other hand, there seems to be a tendency to withhold one's thoughts as long as possible. In so far as this tendency is based upon desire for exclusive use of an invention it is unethical and unprofessional. In so far as it is due to modesty, it is mistaken. In either case, it is bad policy from the standpoint of the author, and an unnecessary injury to the Society.

The most hopeful and pleasing developments of the year have been the unvaried and unwavering support that has been accorded the President by his associates on the Board of Government, and the earnest, helpful interest in the Society of many of its members. These features will always remain a delightful memory.

At the conclusion of the address the tellers of election submitted their report, giving the result of the letter ballot. In accordance with the report, the President announced that the following officers had been elected:

President — George B. Francis.
Vice-President (for two years) — Charles T. Main.
Secretary — S. Everett Tinkham.
Treasurer — William S. Johnson.
Librarian — Frederic I. Winslow.
Director (for two years) — Frederic H. Fay.

The meeting then adjourned to partake of the twenty-seventh annual dinner which was served in the auditorium of the Club House. The attendance at the dinner was 160 members and guests.

After the dinner President Worcester again called the meeting to order and in a very happy manner introduced the president-elect, Mr. George B. Francis.

Mr. Francis thanked the members for the great honor they had conferred upon him and alluded particularly to the fact that, as he was a non-resident member, he appreciated even more highly his election. He

then gave a very interesting talk on "Railroad Terminals," which was fully illustrated by lantern slides. The talk included a history of the terminal problem in the city of Providence, R. I., and descriptions of terminals in many cities in this country and abroad.

At the conclusion of the talk the annual meeting was adjourned.

S. E. Tinkham, *Secretary.*

The smoker held in the evening in the auditorium of the Boston City Club was an occasion thoroughly enjoyed by the two hundred and fifty or more persons present, and it contributed so largely to the spirit of sociability and good fellowship that the hope was generally expressed that the Society might have such gatherings regularly in the future. Ample opportunity was afforded for greeting old and making new acquaintances. After partaking of light refreshments, during which time music was provided by an orchestra, the greater part of the evening was given to the singing of old-time songs as well as new songs written for the occasion by some of the members and containing local hits. The smoker was a fitting ending of the most successful annual gathering in the history of the Society.

Annual Report of the Board of Government for the Year 1908–9.

Boston, Mass., March 17, 1909.

To the Members of the Boston Society of Civil Engineers:

In compliance with the requirements of the constitution, the Board of Government submits its report for the year ending March 17, 1909.

At the last annual meeting the total membership of the Society was 650, of whom 618 were members of the Society, 1 honorary member, 13 associates and 18 were members of the Sanitary Section only.

During the year the Society has lost a total of 36 members: 13 by resignation, 17 by forfeiture for non-payment of dues, and 6 have died.

There has been added to the Society during the year a total of 64 members in all grades; 58 have been elected and 2 reinstated to membership in the Society, and 4 have been elected to membership in the Sanitary Section. Two members, Joseph P. Davis and Erasmus D. Leavitt, have been made honorary members.

The present membership of the Society consists of 3 honorary members, 11 associates and 664 members, of whom 19 are members of Sanitary Section only; making the total membership 678.

The record of the deaths during the year is:

William V. Moses, died April 14, 1908.
Irving T. Farnham, died September 19, 1908.
George Edward Sleeper, died October 25, 1908.
Arthur W. Hunking, died November 12, 1908.
Charles D. Elliot, died December 10, 1908.
Timothy Guiney, died February 4, 1909.

At the time of his death, Mr. Farnham was a Director of the Society and Clerk of the Sanitary Section.

Nine regular and three special meetings of the Society have been held during the year. The average attendance at the regular and special meetings was 82, the largest being 164 and the smallest 25.

The following papers have been read at the meetings:

March 18, 1908. — William F. Williams, "The Abolition of Grade Crossings in New Bedford." (Illustrated.)

April 15, 1908. — George F. Swain, "Some Points in Connection with the Quebec Bridge." (Illustrated.) Memoir of Alfred E. Nichols.

May 20, 1908. — James E. Howard, "Some Causes which Tend Toward the Fracture of Steel Rails." (Illustrated.) Discussion by Prof. Henry Fay and members of the Society. Memoir of William V. Moses.

July 4, 1908. — Sixtieth Anniversary of Organization of Society. Addresses by President Joseph R. Worcester, Past Presidents William E. McClintock, Dexter Brackett, and Frank W. Hodgdon, and Messrs. George B. Francis and Morris Knowles. Subject: "Why do not Engineers take a more Prominent Part in Public Affairs?"

September 16, 1908. — Benjamin Fox and Sanford E. Thompson, "Notes on Driving Cast Reinforced Concrete Piles." (Illustrated.) M. M. Cannon, member of American Society of Civil Engineers, "Steamship Terminals at Brunswick, Ga., and Pier at Navy Yard, Charleston, S. C." (Illustrated.)

October 21, 1908. — Dr. Edward V. Huntington, of Harvard University, "A Study of the Motion of the Gyroscope, with Special Reference to the Brennan Mono-Rail Car." (Illustrated.) I. N. Hollis, "Application of Gyroscope to the Howell Torpedo."

November 18, 1908. — J. G. Callan, "The Small Steam Turbine Considered from an Engineering and Commercial Viewpoint." (Illustrated.)

December 11, 1908. — Meeting held at Boston City Club. Discussion of Report of Committee on Larger Membership and Club House.

December 16, 1908. — Frederic H. Fay, Charles M. Spofford and John C. Moses, "Boylston Street Bridge, Boston, from 1888 to the Present Time; the Destruction and Reconstruction of a Bridge Subjected to Locomotive Fumes and Increasing Car Loads." (Illustrated.)

January 13, 1909. — Desmond FitzGerald, "Principal Docks and Harbors of Europe." (Illustrated.)

January 27, 1909. — H. K. Higgins, "A Specification for Filing and Indexing Railroad Plans." Alfred D. Flinn, "The Filing and Indexing Systems of the Board of Water Supply of the City of New York." Herbert C. Hartwell, "The System of Indexing Plans used by the Boston Elevated Railway Company, in the Department of Elevated and Subway Construction." (Illustrated.)

February 17, 1909. — Henry M. Haven, "Mechanical Refrigeration and Some of Its Modern Applications." (Illustrated.)

Three informal meetings have been held in the Society's library during the year.

December 10, 1908. — Mr. Frederick S. Green, Vice-President of the Waterproofing Company of New York, "Hydrolithic System of Waterproofing." (Illustrated.)

February 10, 1909. — Municipal Engineers' Meeting. Lewis M. Hastings, "Location of Pipes and Conduits of Public Service Corporations." Frank O. Whitney, "Preparation of Plans for Assessment of Betterments in Boston and the Laws Governing the Same." Arthur Bartlett, "Method of Obtaining and Preparing Transfers of Property for Use in Assessors' Department."

March 10, 1909. — Austin B. Fletcher, "First International Road Congress."

The sixtieth anniversary of the foundation of the Society was observed in a most fitting manner by the excursion to Bretton Woods. The occasion attracted some of our members who are rarely able to attend the regular meetings in Boston, and the five days of close association resulted in friendships which ordinarily would not be formed in as many years. The attendance of the old guard of past presidents and their fraternal spirit towards the future presidents was perhaps the most delightful feature.

The library has continued to gain in value under the efficient management of the Librarian, and has been patronized to a considerable extent by

members. The Board recommends the continued appropriation for this purpose of as large a sum as can be spared.

The suggestion made at the last annual meeting that an effort should be made to make the Society more interesting to engineers residing in our vicinity was referred to a special committee, of which the originator of the suggestion was chairman. This committee has given faithful and earnest consideration of the subject and has presented two reports to the Society, including numerous and valuable recommendations. The Board of Government has endeavored to carry out these suggestions as far as possible, one resulting in the very enjoyable special meeting at the City Club in December, and another in the form adopted for the present annual meeting. Further benefit is to be expected from them in the future. The matter of the possible change in quarters being still under discussion, the Board renewed our lease of the present accommodations for a term of five years but with a proviso that the lease may be cancelled by either party before the expiration of the term upon a notice of six months.

The question of the formation of additional sections of the Society has been considered by the Board, and, in view of the success which has attended the Sanitary Section since its formation, there can be no doubt of the desirability of further development in this direction. A committee has been appointed to investigate the feasibility of organizing a Mechanical Section, but as yet the committee has not reported. In many ways a sectional meeting is more satisfactory than a general meeting. The members become better acquainted with each other, and the social atmosphere is more conducive to true fellowship. The varying programs presented at the general meetings attract, to some extent, different groups of members, but the result is that out of our ten regular meetings there may not be more than one or two which appeal particularly to any one man, and going to these only he would have little chance to become well acquainted with his fellow-members. If we had a number of sections, the number of general meetings might be reduced to three or four, which would be very largely attended.

The success of sections, however, it must be clearly understood, depends entirely upon the enthusiastic support of a few leaders. Without this leadership not only would it be difficult to organize a section, but impossible to maintain it. The Sanitary Section has been extremely fortunate in this respect, and great credit is due its officers.

The work of the Secretary has been gradually increasing from year to year, while the Society has been passively content to impose upon the good nature of our faithful member who has devoted unstinted time and patience to the carrying on of our business. The time has come when this situation must be immediately faced. The editing of the *Bulletin*, the sending out of frequent notices, the correspondence with members and others, the arrangements with stenographers and illustrators for meetings, the following up of authors to secure manuscripts and innumerable other matters would nearly fill the entire time of an assistant. Moreover, if we had an assistant, the other officers, the Treasurer, the Librarian, the Clerk of the Sanitary Section and others could make profitable use of a part of his spare moments. If, in addition, the Society could secure a permanent custodian of the rooms, who would be familiar with the library and could answer questions, we feel sure that the value of the rooms would be largely enhanced to members. This assistant need not be an engineer

and might be a woman. It would be best to have a stenographer and one familiar with bookkeeping. By allowing this person to take in outside work, the expense to the Society might be somewhat lessened, but undoubtedly we shall have to spend \$500 or \$600 per year more than at present, even if a portion of the present salary of the Secretary be devoted to the purpose.

For several years the current receipts have been just about sufficient to meet the necessary expenses, and the outlook for the future is that there will be no decrease in any of the items of our expense account. The Board recommends a full discussion of this subject, and that definite action be taken.

For the Board of Government,
JOSEPH R. WORCESTER, *President.*

ABSTRACT OF THE TREASURER'S AND SECRETARY'S REPORTS FOR THE YEAR 1908–1909.

CURRENT FUND.

Receipts:		
Dues for 1908–1909	\$4 014.00	
Dues for 1909–1910	85.00	
Dues for 1888–89 and 1903–4	14.00	
Rent of rooms	1 000.00	
Advertisements	1 105.00	
Library fines	4.24	
Balance on hand, March 18, 1908	590.03	
		\$6 812.27
Expenditures:		
Rent	\$2 010.00	
Lighting	36.30	
Association of Engineering Societies	1 329.50	
Printing, postage and stationery	1 544.16	
Salaries of Secretary, Librarian and Custodian	550.00	
Reporting meetings	100.00	
Stereopticon	165.00	
Books	53.35	
Binding	145.20	
Periodicals	28.50	
Cleaning library	38.25	
Furniture and repairs	33.50	
Advertisements in JOURNAL	15.00	
Incidentals	32.94	
Insurance	8.88	
		6 090.58
Balance on hand, March 17, 1909		\$721.69
Amount to credit of Current Fund, March 18, 1908		590.03
Excess of receipts over expenditures during year		\$131.66

PERMANENT FUND.

Receipts:		
Fifty-eight entrance fees, Society	$580.00	
Four entrance fees, Sanitary Section	20.00	
Interest on deposits	180.72	
Interest on bonds	456.00	
Subscription to Building Fund	100.00	
Merchants' Co-operative Bank, retired share	202.88	
Balance on hand, March 18, 1908	1 519.58	
		$3 059.18
Expenditures:		
Merchants' Co-operative Bank, dues on shares	$300.00	
Volunteer Co-operative Bank, dues on shares	300.00	
Workingmen's Co-operative Bank, dues on shares,	300.00	
Franklin Savings Bank, deposit	19.68	
Warren Institution for Savings, deposit	29.56	
Boston Five Cents Savings Bank, deposit	28.40	
Provident Institution for Savings, deposit	27.80	
Eliot Five Cents Savings Bank, deposit	22.06	
Institution for Savings in Roxbury, deposit	20.58	
		1 048.08
Balance on hand, March 17, 1909		$2 011.10

PROPERTY BELONGING TO THE PERMANENT FUND, MARCH 17, 1909.

Twenty-five shares Merchants' Co-operative Bank	$3 304.76
Twenty-five shares Volunteer Co-operative Bank	3 561.25
Twenty-five shares Workingmen's Co-operative Bank	847.62
Deposit in Franklin Savings Bank	507.14
Deposit in Warren Institution for Savings	761.77
Deposit in Boston Five Cents Savings Bank	732.05
Deposit in Provident Institution for Savings	716.79
Deposit in Eliot Five Cents Savings Bank	568.24
Deposit in Institution for Savings in Roxbury	530.53
Republican Valley Railroad Bond, 6%, par value	600.00
Boston Elevated Railway Bonds, 4½%, par value	4 000.00
C. B. & Q. Railroad Joint Bonds. 4%, par value	3 000.00
American Tel. & Tel. Co. Bonds, 4%, par value	3 000.00
Cash on deposit	2 011.10
Total Permanent Fund	$24 141.25
Amount of fund as per last annual report	22 455.02
Gain during the year	$1 686.23

TOTAL PROPERTY OF THE SOCIETY IN THE POSSESSION OF THE TREASURER.

Permanent Fund	$24 141.25
Current Fund	721.69
Total	$24 862.94
Amount as per last annual report	23 045.05
Increase during year	$1 817.89

Report of the Committee on Excursions.

To the Members of the Boston Society of Civil Engineers:

During the past year nine excursions have been made by the Society, as follows:

April 15, 1908. — Charles River Dam. Attendance, 42.
May 20, 1908. — Washington Street Tunnel. Attendance, 74.
June 12, 1908. — Newton, Riverside and Norumbega Park. Attendance, 54.
July 3 to 5 (inclusive), 1908. — Bretton Woods, N. H. Attendance, 62.
September 9, 1908. — Wonderland, Revere. Attendance, 27.
September 16, 1908. — Charles River Dam. Attendance, 75.
October 21, 1908. — Deer Island, Boston Harbor. Attendance, 31.
November 18, 1908. — Northern Avenue. Attendance, 65.
January 27, 1909. — General Electric Company's Works, Lynn. Attendance, 32.

Total attendance, 462; average attendance, 51.

The committee has continued to collect such data in regard to "new engineering work" in process of construction, as has been obtainable for publication in the *Monthly Bulletin* of the Society, and in the course of the year has contributed about forty-three pages of such information.

In September last Mr. E. M. Blake, who had served the committee well in the capacity of Secretary and Treasurer, was called away to the western part of the country and Mr. H. K. Barrows was appointed to fill the vacancy caused by his resignation.

The thanks of the committee are hereby extended to all persons who have rendered assistance of any kind, and the suggestion is offered that still further coöperation will be welcome and that all helpful suggestions will be gratefully received. It is especially called to your attention that in the matter of promptly sending reply postal cards regarding attendance on excursions, members can be of material assistance to the committee in charge.

The Treasurer's report, hereto appended, shows a balance in the hands of the committee of $14.54.

Respectfully submitted,

E. E. Pettee, *Chairman*,
L. B. Manley,
Harold K. Barrows,
Ralph W. Loud, *Secretary*,
Committee on Excursions.

Boston, Mass., March 17, 1909.

Report of the Committee on the Library.

The report of the Library Committee for the past year is herewith submitted.

The number of books added to the library has been 187 bound in cloth and 212 in paper. Twenty-two volumes were purchased, the remainder being given to the library, 7 being the gift of Mr. Clemens Herschel. The total number of bound volumes now on the shelves is 6 445.

During the twelve months, 191 books have been loaned to members. Thirty volumes of municipal reports have been bound in cloth, pursuant to vote of the Society, each volume covering about twelve years.

A twelve-drawer plan case was purchased for the preservation of the government topographical sheets, now numbering several thousands. It is proposed to add more sections to this case as soon as means permit.

During the summer the books and shelves were thoroughly cleaned by the vacuum process.

Many of the old books have had to be rebound as the leather bindings were cracked and falling to pieces. These were rebound in art vellum.

A number of the gifts of Mr. Clemens Herschel have been bound in conformity with our agreement with him in accepting his donations. The committee recommends that the sum of $50 be appropriated for the purchase of new reference or text-books during the coming year.

FREDERIC I. WINSLOW,
MAYO T. COOK,
WILLIAM T. BARNES,
HENRY A. VARNEY,
Committee.

REPORT OF COMMITTEE ON LARGER MEMBERSHIP AND CLUB HOUSE.

BOSTON, March 17, 1909.

To the Members of the Boston Society of Civil Engineers:

The Committee on Larger Membership and Club House begs leave to submit the following report:

At the special meeting of the Society held at the City Club on December 11, 1908, it was voted:

"That it is the sense of this meeting that a bureau of registration for members seeking employment or a change of position should be established by this Society, and that the Committee on Larger Membership and Club House be instructed to formulate a plan for the establishment of such a bureau and report the same to the Society."

Your committee has considered this matter, always realizing that the consummation of this idea must be attended by a minimum expenditure of time by the officials of the Society. It is suggested that a suitable two-drawer cabinet for 4 by 6-inch cards be purchased for this purpose. The exact method of filing has not been decided upon, but it would seem advisable to invite all members to file cards giving a brief synopsis of their engineering career. A list of the names of those seeking positions should be kept by the secretary or custodian so as to be readily accessible to those interested, the experience of the applicants to be filed in the card catalogue.

It is deemed an opportune time to call the attention of the Society to the apparent necessity and advantages of a broader and more specific classification of membership, covered by Article 2 of the Constitution.

It is believed that full membership in the Society should require higher qualifications in the way of experience and education, with possibly some minimum age limit to be determined. While the life of the Society depends to a large extent upon the addition of younger members, it is thought that some period of probation in the form of an intermediate grade should be required. The establishment of such a division, probably called "Junior Membership," would lend greater dignity to the Society, create an incentive to attain full membership by the younger men and give a value to full membership perhaps not now existing.

In the event of the Society looking with favor upon the establishment of a club house, briefly outlined in our previous report, it would seem desirable to consider making some provision for student membership, to include possibly only the upper classes of nearby technical schools, this class of membership to have possibly somewhat restricted privileges and smaller dues.

The advantages of this student membership to the student would be the opportunity of attending meetings, acquaintance and association with the older members, with whom perhaps they may be later connected in professional work, and the privileges of the library. The advantages to the Society would be the greater number of young and enthusiastic members, a large percentage of whom would probably desire promotion to the "Junior" grade, and to full membership in due time.

The following statistics concerning the membership and Permanent Fund of the Society may prove of interest:

Year.	Members.	Permanant Fund.
1899	484	$9 253
1900	490	10 010
1901	500	12 788
1902	507	13 651
1903	509	14 999
1904	528	16 081
1905	592	17 614
1906	621	18 813
1907	635	20 058
1908	650	22 455
1909	678	24 141

Respectfully submitted,

LUZERNE S. COWLES,
CHARLES B. BREED,
GEORGE A. CARPENTER,
RALPH E. CURTIS,
EDWARD S. LARNED,
Committee.

REPORT OF THE EXECUTIVE COMMITTEE OF THE SANITARY SECTION.

At the annual meeting of the Section, held March 4, 1908, the reports of the committees for the preceding year were placed on file. The Committee on Run-off was continued, and Messrs. Arthur T. Safford and William S. Johnson were added to the committee. At this meeting a Committee on Collection and Tabulation of Sewerage Statistics was appointed, and at the special meeting held on April 1 a committee of five was appointed to consider the subject of uniform specifications for the manufacture of vitrified sewer pipe. The Committee on Run-off suffered by the death of Mr. Irving T. Farnham, who was chairman of the committee. Mr. H. K. Barrows was appointed in his place at the December meeting.

On June 3 an excursion to Lawrence and Lowell was arranged. Arriving at Lawrence in the morning, the members visited the Experiment Station of the Massachusetts State Board of Health and later the new pumps and filters of the Lawrence Water Works. The party arrived

at the Vesper Club above Lowell in the early afternoon, and after dining spent an enjoyable period on the beautiful island belonging to the club. Of especial interest was the new suspension bridge across the Merrimac River. On the return to Lowell the party were shown the wells and pumping station of the Lowell Water Works.

The death of Irving T. Farnham, Clerk of the Section, during the summer was a great loss. Mr. Farnham was much beloved by his associates, who mourn that failing health caused his mind to temporarily lose its control, and in the darkness of that hour death came. The unceasing energy with which he attacked all his work was unsparingly used to promote the interests of this Section.

In October a regular meeting of the Section was held at the Boston City Club. Messrs. Gardner S. Gould and Raymond W. Parlin were elected members of the Section, and Robert Spurr Weston was elected Clerk. During the year the following papers have been presented:

March 4. "Water Power." . By Arthur T. Safford.
April 1. "Alaska." By Geo. R. King.
October 7. "Sewage Disposal Works in England and Germany." By Harry W. Clark.
November 4. "Three Years on the Isthmus." By Dr. Sumner Coolidge.
December 2. "Some Anomalies in Modern Plumbing Regulations. By J. Pickering Putnam.
February 3. "Day Labor *vs.* the Contract System for Doing Municipal Work." By Harrison P. Eddy.

All the talks have been illustrated by lantern slides or diagrams and the interest and attendance have been good. Besides the members of the Section, Dr. Charles P. Chapin, Superintendent of Health, Providence, R. I.; Mr. David Craig, President of the Master Plumbers' Association, and Mr. James C. Coffey, Executive Officer of the Worcester Board of Health, have contributed to the discussion of the papers.

The attendance has been as follows:

Annual meeting	35
April meeting	46
June excursion	34
October meeting	40
November meeting	53
December meeting	33
February meeting	62

Exclusive of the June excursion the average attendance at meetings has been 45.

Your Executive Committee passes its work to its successor with the recommendation that efforts be made during the coming year to have the meetings take up practical phases of sanitary engineering work as much as possible, that they may attract municipal officers and practical operators of sanitary works.

For the Executive Committee,

ROBERT SPURR WESTON, *Clerk.*

BOSTON, MASS., March 3, 1909.

The Committee on Run-Off from Sewered Areas submits the following report of its work during the year 1908–9:

The committee has during the past year directed its attention chiefly to arousing an interest on the part of engineers in establishing gaging stations and securing data. To this end the committee has corresponded with a large number of engineers in various parts of the country, and as a result about thirty have expressed a desire to assist, although in many cases the necessary funds for the establishment of stations are lacking, and in other cases the necessary authority for the work cannot be secured from the city governments.

As yet five gaging stations in only five places have been actually established as the result of the work of the committee. These are at Newton, Mass.; Cambridge, Mass.; Lowell, Mass.; Pawtucket, R. I., and Ithaca, N. Y. Records of considerable value are being obtained from the first four of these stations, but as yet the records have not been collated. Records of gagings previously made have been received from Philadelphia, and the committee has been promised a valuable set of observations which were made at Gary, Ill.

While the stations already established will, if continued, furnish valuable data, it is very desirable that as many additional stations as possible be established, and the committee would urge the members of the Section to do all in their power to further this work in their immediate vicinity. The committee will be glad to aid in the establishment of stations by giving advice based on experience obtained in other places, and members of the committee will go over the ground with any who may wish such assistance.

At the beginning of the year the main society appropriated $50 for the expenses of the committee, a part of which has been used for printing blank forms upon which returns of the investigations are to be made.

The committee suffered a great loss in the death of Mr. Irving T. Farnham, who served as chairman since its organization, and to whose efforts the undertaking of this work by the Section was largely due. Besides serving as chairman, Mr. Farnham contributed largely to the results which have so far been obtained by the establishment of stations in Newton, where he was city engineer.

Respectfully submitted,

G. A. Carpenter, *Chairman*,
W. S. Johnson,
A. T. Safford,
H. P. Eddy,
L. M. Hastings,
H. K. Barrows,
H. J. Hughes,
Run-Off Committee.

Boston, Mass., March 2, 1909.

Sanitary Section, Boston Society of Civil Engineers:

Gentlemen, — Your Committee on "Manufacture of Sewer Pipe" submits the following progress report.

Early in its investigations your committee appreciated that, in an attempt to standardize such a commercial project as vitrified pipe, coöperation with the manufacturers as well as a study of current practice

among engineers was desirable. Following this idea letters were sent, bearing upon the subject, to manufacturers of sewer pipe in different parts of the country, to the secretary of the American Society for Testing Materials, and to engineers in different parts of the country, asking for copies of the specifications used by them.

A member of your committee met the representatives of the manufacturers assembled in New York and outlined its plans. The manufacturers appeared to favor the standardization of sewer pipe specifications, and promised to give the matter their careful consideration, and to communicate further with your committee. Various matters have, however, prevented definite action upon the part of the manufacturers up to the present time, but your committee is still hopeful of final success.

Specifications from prominent engineers in different parts of the country have been gathered and are now being collated and analyzed.

A bibliography of the subject has also been prepared.

Your committee is, therefore, unable to make final report at the present time, and asks to be continued.

Respectfully submitted,

F. A. Barbour.
E. S. Dorr.
C. R. Felton.
L. D. Thorpe.
Leonard Metcalf, *Chairman.*

Boston, Mass., February 23, 1909.

Sanitary Section, Boston Society of Civil Engineers, Boston, Mass.

Gentlemen, — Your Committee upon the Collection and Tabulation of Sewerage Statistics begs leave to report upon the work of the last year as follows:

The statistics secured for 1906 were presented in the form of a report, together with tabulations, upon May 8, 1908, and this report was subsequently printed in the Journal of the Association of Engineering Societies, No. 5, Vol. XL, issued in May, 1908. Immediately following the publication of these data the committee undertook to secure the summaries for 1907. This work was completed and a report upon same, together with tabulations, was presented to the Section upon February 3, 1909. The Section voted to have it printed, and it has been forwarded to the Secretary of the Association of Engineering Societies.

In reviewing the work of the year it is interesting to note that Summaries of Statistics for 1907 have been received from 24 cities and towns not included in the tables for 1906. Summaries for 1907 were received from 48 municipalities, and the last water works statistics published by the New England Water Works Association in 1906 contained reports from but 43 municipalities. It would appear from this comparison that the work of the Sanitary Section has met with a reasonable degree of success.

It is very apparent from even a casual study of the statistics furnished that the records in many of the cities and towns are kept in a very indifferent manner. It is encouraging to note, however, that a few officials have adopted this summary for use in their annual reports. The cities

thus reporting data in whole or in part, in accordance with the standard summary, are Cambridge, Newton, Waltham, Watertown and Worcester, Mass., and Providence, R. I. Your committee desires to urge upon the members of the Section, as well as upon engineers and city officials in general, the adoption of this summary, not only for the annual reports, but also for keeping the records of the office. If the system is once adopted it is likely to be continued and improved from time to time.

Attention is called to the fact that the statistics received for 1907 do not in all cases check up with those for 1906. Care should be taken to compare the statistics returned to the committee with those returned previously, so that no errors may creep in, and so that errors made in the past may be corrected.

In view of the incomplete data received, and also of the fact that undoubtedly the data given are not in all cases capable of correct interpretation except by those who prepared them, it may very well be asked whether the value of the data obtained is sufficient to warrant continuing the work. Upon this subject it seems that the results accomplished to date might be summarized as follows:

1. It is apparent and has been pointed out very clearly to municipalities with which your committee has corresponded that data relating to sewerage and sewage disposal are very poorly kept as a rule.

2. A standard form for keeping and for publishing the data in question has been provided and some degree of success has attended the effort made for its adoption.

3. As much information as possible has been collected and published for two successive years, and the information thus placed at the disposal of engineers interested in this subject is sufficient at least to indicate to them the lines of inquiry which may be necessary to secure more reliable information should they individually care to make further investigation.

4. Your committee has taken the liberty of rearranging in tabular form certain of the more interesting data relating to the cost of maintaining sewers, which, together with other information taken from printed reports and published articles, have been included with the tables to be published in connection with the Summary for 1907.

5. The collection of these statistics furnishes a personal connection of no small value between the Section and the various superintendents and engineers directly in charge of the work. Many who do not take active part in the meetings are thus represented. The Section by thus extending its usefulness to as many individual members and non-members as possible will secure a growth and a character of the kind which comes only to the more progressive organizations.

Whatever criticism may be justly made of the value of the data obtained and published, it seems true beyond reasonable doubt that the effort thus far made has resulted in impressing upon some of the engineers and officials the importance of recording valuable data, and has furnished a standard form which can be used with some assurance that others working in a similar field are collecting comparable information. If the work should stop at the present time your committee fears that much of the good which has been accomplished by inducing various municipal officers to realize the value of keeping their data in better form would be lost; while, on the other hand, if the work is carried on for a time it is probable that the results would in more cases be permanent.

The work of collecting data for 1908 has been started and some material has already been received. If this work is to be continued, an effort should be made to publish the available material at as early a date as possible after the expiration of the year to which it applies. Should the Section decide to continue this work, your committee recommends the following changes in the form of summary adopted by the Section:

1. Provide a space for the signature, official title and address of the person furnishing statistics.

2. Add the question, "Is this form used in preparing the annual report of your department for publication?"

3. Add after Item 13, under "Collection," "Number of miles cleaned."

4. Add after Item 18, under "Collection," the item "Cost of maintaining sewer system exclusive of disposal works (including cost of flushing and cleaning sewers; cost of cleaning catch-basins; administration and unclassified expenses)."

5. Add a note properly referenced at the bottom of the last page as follows:

"State what 'repairs' and 'unclassified expenses,' under Maintenance and Operation, include."

6. That all the items included in the summary be numbered consecutively from beginning to end, instead of being numbered under each of several classifications.

Respectfully submitted,

HARRISON P. EDDY.
CHARLES SAVILLE.
BERTRAM BREWER.

Civil Engineers' Society of St. Paul.

ST. PAUL, MINN., MARCH 8, 1909.—The regular monthly meeting of the Civil Engineers' Society of St. Paul was held in the main parlor of the Commercial Club Rooms in the Germania Life Building on Monday evening, March 8, 1909, with President H. J. Bernier in the chair. There were present eighteen members and fifty-eight visitors.

The President introduced the speaker of the evening, Mr. C. A. P. Turner (M. Am. Soc. C. E.), who addressed the meeting on the subject of "Reinforced Concrete," as exemplified in the "Turner Mushroom System." The lecture was freely illustrated with lantern slides and was very interesting and instructive.

The discussion that followed Mr. Turner's address was participated in by a large number of those present.

At the conclusion of the address the regular business of the Society was disposed of. It was duly moved and seconded that the reading of the minutes of the previous meeting be dispensed with.

The resignations of Mr. L. W. Rundlett and Mr. Chas. A. Alderman were read and accepted.

A communication from the Commercial Club of Pittsburg, Penn., urging our Society to adopt a resolution similar to theirs on the subject of inland waterways was read and discussed, with the result that a

committee comprising Messrs. Wolff, Claussen and DuShane was appointed and instructed to draw up a suitable resolution covering the said subject and have it ready for further discussion at our next regular meeting.

A communication from a member, Mr. Oliver Crosby, urging the Society to take an active part on matters of "Public Importance," was read and discussed, but, owing to Mr. Crosby's absence, it was decided to give the matter further consideration at a later meeting.

The applications of Mr. W. S. Batson, Mr. Harold J. Hoard, Mr. W. E. McCullough, Mr. Henry A. Lyon for membership, and Mr. L. G. Couter for junior member, were presented to the Society. Upon motion, it was duly seconded and voted that the Secretary cast the ballot of the Society admitting these gentlemen to membership in the Society as petitioned.

A vote of thanks was then passed to Mr. C. A. P. Turner for his very detailed and instructive address of the evening.

The meeting thereupon adjourned.

D. F. JURGENSEN, *Secretary.*

Utah Society of Engineers.

SALT LAKE CITY, FEBRUARY 19, 1909. — The conservation of the natural resources of the intermountain country was the subject considered at the meeting of the Utah Society of Engineers in the auditorium of the Packard Library, February 19. Joseph F. Merrill, president, directed the proceedings, and there was a large attendance.

The first speaker was O. J. Salisbury, who was one appointed by the governor to represent Utah at the conference held at Washington last December on the subject of conservation. He urged coöperation among the various states, and between them and the national government. Each state must appoint a conservation commission, and he thought it was high time Utah was taking steps in the matter. A bill was being prepared, he said, and will be presented to the state senate, providing for the establishment and maintenance of such a commission.

Clyde Leavitt, district forester of the forestry service, the next speaker, said almost all of the timber lands in Utah are now included in the forestry conservation, so the burden falls mainly upon the federal government. The forestry service had been fortunate in Utah, he said, many of the people having petitioned for it. The natural resources had been impaired in the past and it was for the present generation to say whether the resources shall be repaired. The present supply of timber at the present consumption would not last more than thirty-three years, as it is being cut three and a half times faster than it grows. Forestry was being practiced on 70 per cent. of the public lands and less than 1 per cent. on private lands. The annual loss from forest fires, Mr. Leavitt said, was $50 000 000. In 1902, when the lands were administered by the land office, five and a half acres in every thousand were destroyed annually by fire, and under the administration of the forest service last year less than one acre per thousand was destroyed. Last year the fire patrol saved $34 000 000 of timber. He declared that the national forests were not

created to regulate the grazers; the purpose was the preservation of the timber to future generations and the protection of the watershed. Last year the government derived from the grazers a revenue of $962 000.

Markham Cheever, of the Telluride Power Company, discussed "Water Power." He said precipitation varies throughout the year and the stream flow fluctuates greatly. It was, therefore, essential to conserve the water during the flood season to use it in the dry season. He described the various natural and artificial means of conservation and referred to the dams and reservoirs of the government for irrigation, which he commended. He believed that in time distant reservoir sites will be developed for power, and declared that the inefficiency of the power plant was not due to the plant, but rather to the failure to utilize the stream flow to best advantage. He advocated auxiliary storage and an increase of the natural reservoirs.

W. D. Livingston, general manager of the Irrigated Lands Company, spoke on "Irrigation." He devoted himself to the legal phase of the question in the main. He referred to the immense amount of litigation which had arisen over water rights, and said they would never be finally adjusted until expert engineers were employed to do the practical work He declared that farmers were using 50 per cent. too much water where they had the water to use, and declared that water could do double the duty that it was doing.

Robert H. Bradford, of the State University, talked on the mineral resources of Utah. He stated that Utah is the peer of any state in the production of the four metals, gold, silver, copper and lead. He spoke of the methods employed by the smelters, their close and economic reduction of ores, and asserted that they will yet use more improved methods.

"The Fuel Supply" was dealt with by Daniel Harrington, formerly engineer for the Utah Fuel Company. Mr. Harrington said that about one third of 1 per cent. of the fuel deposits of the country had been exhausted, so there was little fear of a fuel famine. Utah has 15 130 acres of coal land and the tonnage it was supposed to originally contain was 196 458 000 000. Of this, 28 000 000 tons have been exhausted. By this, he explained that 18 800 000 tons had been produced and 9 200 000 tons had been wasted — about 33 per cent. He spoke at great length on the waste of fuel and stated, among other things, that the get-rich-quick methods were responsible for the waste of coal as well as timber.

E. C. Lackner was the last speaker. He arraigned the national administration for meddling in state affairs.

D. McNicol, *Secretary.*

Salt Lake City, Utah, March 19. 1909. — The matter of arranging for the annual banquet, to be held about the middle of April, was placed in the hands of the Entertainment Committee, consisting of Messrs. M. D. Grosh, R. R. Lyman and C. P. Overfield.

For the purpose of submitting nominations for officers for the year commencing June 1, 1909, a committee was appointed consisting of Messrs. D. McNicol, Sidney Bamberger, B. F. Tibby and J. C. Hornung. The results of the election will be announced at the annual banquet.

At the March 19 meeting, Mr. L. H. Krebs, assistant city engineer,

read a paper dealing with "The Sewerage System of Salt Lake City." The paper was highly interesting and was freely discussed by the members present.

Mr. O. H. Skidmore, city electrical engineer, presented a paper with the subject, "The System of Keeping Records in the City Engineer's Office, Salt Lake City." Mr. Skidmore gave a clear description of the methods employed for keeping complete and accurate records of the various departments of the city engineer's office, and had on exhibition samples of the forms and files used.

D. McNicol, *Secretary.*

Montana Society of Engineers.

Butte, Mont., March 13, 1909. — The monthly meeting of the Society for March was held in the Society room on the above date, with President C. H. Bowman presiding. Quorum present.

The minutes of the February meeting were read and approved.

The Secretary reported the purchase of a magazine rack and book shelves in accord with instructions. On motion, the Secretary was instructed to request an exchange of library and society room privileges with the Utah Society of Engineers.

A portion of a letter furnished by a member of the Society, written by a former member of the United States Geological Survey, having for its subject "Mining Operations in Korea and China," giving a clear account of labor and financial conditions in those regions, was read and caused much discussion and interesting comment. The letter was accompanied by many photographs, showing mines in operation, with crude appliances, and various scenes of historic interest.

Adjournment followed.

Clinton H. Moore, *Secretary.*

Association of Engineering Societies.

Vol. XLII. | April, 1909. | No. 4.

PROCEEDINGS.

Engineers' Club of St. Louis.

St. Louis, March 3, 1909. — The 665th meeting of the Engineers' Club of St. Louis was held at the Club Rooms on Wednesday evening, March 3, 1909, at 8.30 o'clock, President Wall presiding. There were present twenty-nine members and twelve visitors.

The minutes of the 664th meeting were read and approved. The Secretary presented a brief statement of the proceedings of the 459th meeting of the Executive Committee.

The following were elected: Robert P. Garrett (member); William J. Brown (member); Alfred C. Einstein (member); John P. Materne (associate member).

The following applications were presented: John B. Emerson (for membership); Taliaferro Milton (for membership).

Mr. H. A. Wheeler than presented a very interesting paper on "Gas and Oil in the St. Louis District." He outlined the geological conditions necessary for the presence of oil and gas, and showed how conclusions of geologists had been verified in every respect by the oil and gas wells of Pennsylvania, Ohio, Illinois, Kansas, Oklahoma, Texas, Colorado and California. At the conclusion of the address the discussion was participated in by a number of those present.

Adjourned.

A. S. Langsdorf, *Secretary*.

St. Louis, March 17, 1909. — The 666th meeting of the Engineers' Club of St. Louis was held at the Club Rooms on March 17, 1909, at 8.30 o'clock, President Wall presiding. There were present fifty-three members and twenty-eight visitors. The minutes of the 665th meeting were read and approved, and the minutes of the 460th meeting of the Executive Committee were read.

The following were elected: J. B. Emerson (member); T. Milton (member).

The following applications were read: E. G. Hooper (for membership); T. E. Flaherty (for associate membership).

There being no further business, the President introduced Mr. E. T. Adams, of the Allis-Chalmers Company, of Milwaukee, who presented an informal address on "Recent Gas Engine Installations." Mr. Adams traced briefly the various steps that have characterized the evolution

of the gas engine to its present state, and described some of the more noteworthy installations of large units, especially those at Gary, Ind., and at the plant of the Illinois Steel Company in South Chicago. A large number of lantern slides was used to show the details of the engines at these and other plants. At the conclusion of the address a unanimous vote of thanks was tendered to Mr. Adams and to the Allis-Chalmers Company for this very interesting and instructive address.

The meeting then adjourned to the adjoining rooms, where the Entertainment Committee had provided light refreshments and cigars.

A. S. Langsdorf, *Secretary.*

Boston Society of Civil Engineers.

Boston, April 21, 1909. — A regular meeting of the Boston Society of Civil Engineers was held at Chipman Hall, Tremont Temple, at 7.50 o'clock p.m., President George B. Francis in the chair; sixty members and visitors present.

On motion, duly seconded, it was voted to dispense with the reading of the record of the annual meeting inasmuch as it had been printed in full in the April *Bulletin.*

Messrs. Charles E. Allen, Howard B. Luther, Herbert C. Poore, Edwin H. Rogers, Willard C. Tannatt, Jr., and Alden S. Tileston were elected members of the Society, and Arthur I. Negus an associate of the Society.

The Secretary reported for the Board of Government that under authority of the vote passed at the annual meeting, referring to the Board, with full powers, the question of appointing the special committees of the Society and the selection of the members thereof, the following committees had been appointed:

On Excursions: H. K. Barrows, chairman; Frank H. Carter, secretary; F. L. Murray, L. G. Morphy and H. L. Coburn.

On the Library: F. I. Winslow, L. G. Thorpe, H. T. Stiff, J. M. Siner and E. R. Olin.

On Permanent Quarters and Larger Membership: Desmond Fitz-Gerald, E. W. Howe, J. R. Worcester, J. W. Rollins, Jr., L. S. Cowles, G. A. Carpenter, R. E. Curtis, C. B. Breed, E. S. Larned and J. H. O'Brien.

The Board also appointed the following to represent the Society on the Board of Managers of the Association of Engineering Societies, in addition to the Secretary, who is *ex officio* a member: Dexter Brackett, C. W. Sherman, G. A. Kimball, H. P. Eddy, A. T. Safford and J. R. Worcester.

The Secretary read a memoir of Timothy Guiney, a member of the Society, prepared by a committee consisting of Messrs. J. L. Howard and J. N. Ferguson.

The President announced the death of Lewis Frederick Rice, a past president of the Society, which occurred on April 12, 1909, and it was voted that a committee be appointed to prepare a memoir. The President has named as this committee, Messrs. Joseph P. Davis and George S. Rice.

Mr. E. W. Howe, for the Committee on Permanent Quarters, made a verbal report in relation to the property at 10 Ashburton Place, and as to its availability for a Society house.

The Secretary submitted a vote which had been prepared by the Board of Government and the Committee on Permanent Quarters in joint session, and which, if passed by the Society at two successive regular meetings, would render the Permanent Fund available for immediate use in the purchase of a Society house.

Voted: That the Board of Government be authorized to use the Permanent Fund for the purchase and equipment of a house for the Society.

On a vote being taken it was carried, thirty-five voting in the affirmative and one in the negative.

The Secretary offered in writing the following amendment to the By-Laws:

Amend By-Law 10 by inserting in the first paragraph before the word "year" in the sixth and eighth lines the word "fiscal," so that the paragraph should read:

"New members shall not be liable for the annual dues for the *fiscal* year in which they are elected, and if elected after October 1 they shall be liable for only one half of the annual dues for the ensuing *fiscal* year."

On motion of Mr. Barrows, the thanks of the Society were voted to Mr. James H. Hustis, assistant general manager of the Boston & Albany Railroad, and other officials of that company, for courtesies extended to the members of the Society on the occasion of the visit to the freight terminals of the road at Allston and East Cambridge this afternoon.

Mr. E. B. Allardice was then introduced and read a paper entitled, "Reforestation of the Marginal Lands of the Wachusett Reservoir of the Metropolitan Water Works."

Mr. Arthur A. Shurtleff, landscape architect, of Boston, followed with a very interesting account of the work that had been done by the Metropolitan Water Board and the Metropolitan Park Commission to preserve and improve the trees and forests in connection with their constructions.

Prof. Austin Cary described what had been done abroad, particularly in Germany, to preserve the forests, and Mr. Frank William Rane, state forester, spoke briefly of the work the Commonwealth had done toward preserving our forests.

The lantern was used to illustrate the paper and the descriptions of Messrs. Shurtleff and Cary.

After passing a vote of thanks to Mr. Shurtleff and Mr. Rane, who are not members of the Society, for their courtesy in being present and joining in the discussion, the meeting adjourned.

S. E. Tinkham, *Secretary.*

Boston, May 5, 1909. — A special meeting of the Boston Society of Civil Engineers was held at Lorimer Hall, Tremont Temple, at 8.15 o'clock P.M., President George B. Francis in the chair and more than seven hundred members and visitors present.

The meeting was called to hear the latest information in relation to the Panama Canal, and especially the results of the observations made by the Board of Engineers appointed to accompany President-

elect Taft to the Isthmus, of whom three, Frederic P. Stevens, John R. Freeman and Allen Hazen, were members of this Society. Unfortunately, Mr. Freeman who had expected to take part in the meeting was obliged to go South, but Mr. Stearns and Mr. Hazen were present and gave very interesting descriptions of the work at Panama.

Mr. Stearns devoted a large part of his time to a discussion of the type of canal which had been adopted, and replied to some of the criticisms which have been urged against a canal with locks.

Mr. Hazen spoke more particularly of the conditions of the people and the country in Panama. A large number of stereopticon views were shown to illustrate the remarks of both the speakers.

S. E. TINKHAM, *Secretary.*

Civil Engineers' Society of St. Paul.

ST. PAUL, MINN., APRIL 12, 1909. — The regular monthly meeting of the Civil Engineers' Society of St. Paul was held in the main parlor of the Commercial Club Rooms in the Germania Life Building, on Monday evening, April 12, 1909, with President H. J. Bernier in the chair. There were present ten members and sixteen visitors.

The President introduced the speaker of the evening, Mr. James B. Gilman, chief engineer of the Minneapolis Steel and Machinery Company, who addressed the meeting on "Manufacture and Uses of Structural Steel." Mr. Gilman traced the ore from the mines, to and through the furnaces, to the rolls and cooling beds, to the finished product in the yard. He also gave some excellent advice on design in general, and shop practice, pointing out where savings could be made in costs by the judicious selection of shapes. He also touched on the differences between the Bessemer and Open Hearth processes of manufacture.

At the close of the address the regular business of the Society was taken up. The minutes of the previous meeting were read and approved. The applications for full members, of Mr. Sidney Gardner Jones and Jorgen M. Simmons, were presented, and it was moved, seconded and voted that they be elected to membership as petitioned.

The committee having in hand the drawing up of a resolution on the subject of "Inland Waterways" was given further time, owing to the absence from the city for the past month of the chairman, Mr. J. D. DuShane.

A committee consisting of Messrs. Oscar Claussen, chairman, L. P. Wolff, C. L. Annan, Oscar Palmer and H. J. Bernier was appointed to look up new permanent quarters for the Society, on account of the Society's having been deprived of its quarters in the city hall, to report to the government at a date to be fixed later. The committee was urged to get together forthwith and lose no time in securing such new and suitable quarters.

A vote of thanks was extended to Mr. James B. Gilman for his interesting address.

The meeting thereupon adjourned.

D. F. JURGENSEN, *Secretary.*

Detroit Engineering Society.

FIFTEENTH ANNUAL MEETING AND BANQUET, APRIL 23, 1909. — The meeting was held at the Cadillac Hotel and was called to order by Mr. F. C. Shenehon, President, at 8.15 P.M.

The minutes of the 117th regular meeting were read and approved.

Moved by Williams-Parks, that the seven applications for membership be balloted on collectively on the first ballot. Carried.

The following were elected unanimously:

Messrs. Lewis M. Ellis, manager, Gray Motor Company; W. DeMott Guy, draftsman, 178 Sheridan Avenue; Sidney E. Johnson, contracting engineer, Union Trust Building; H. B. Keeney, draftsman, 16 Charlotte Avenue; Geo. H. Kimball, consulting engineer, 516 Penobscot Building; John A. McDace, draftsman, 232 Jefferson Avenue; Arthur A. Meyer, draftsman, Edison Illuminating Company.

As the report of the Secretary-Treasurer for the year 1908–09 has been printed and mailed to each member of the Society, its reading was omitted by order of the President.

Moved that the report of the Secretary-Treasurer be accepted. Carried.

The Society then proceeded with the annual election, and the following officers were elected for the year 1909–10:

President, Wm. R. Kales, of the firm Whitehead & Kales.

First Vice-President, T. F. McCrickett, engineer, Russel Wheel and Foundry Company.

Second Vice-President, Ralph Collamore, secretary, Smith, Hinchman & Grylls.

Secretary-Treasurer, George H. Fenkell, civil engineer, Board of Water Commissioners.

The Society then adjourned to the banquet room in the Cadillac Hotel, and one hundred and twenty-four members and eight guests participated in the fifteenth annual banquet of the Society.

The program following the supper was as follows:

1. QUARTETTE. Mr. Otto S. Zelner, Mr. E. Hugh Smith, Dr. W. R. Alvord and Dr. C. Shafor.
2. INTRODUCTORY. Mr. F. C. Shenehon, President.
3. A TOAST, "The Training of the Engineer," by Prof. Gardner S. Williams.
4. TENOR SOLO. Mr. A. F. Dierkes, accompanied by Walter Dierkes.
5. A TOAST, by Hon. Philip Breitmeyer, mayor of the city of Detroit.
6. QUARTETTE.
7. A TOAST, by Mr. John Trix, president of the Employers' Association.
8. A TOAST, "The Poor Engineer," by Mr. Granger Whitney.
9. TENOR SOLO. Mr. A. F. Dierkes.
10. A TOAST, by Mr. L. C. Sabin.
11. A TOAST, by Mr. Walter S. Russel.
12. A TOAST, by Mr. T. H. Hinchman, Jr.
13. A TOAST, by Dr. H. C. Sadler.
14. QUARTETTE.
15. Turning over meeting to the President-elect.
16. ADDRESS OF PRESIDENT-ELECT WM. R. KALES.

Adjourned.

GEORGE H. FENKELL,
Secretary-Treasurer.

Annual Report of the Secretary-Treasurer for the Year ending April 23, 1909.

MEMBERSHIP.

Members in good standing April 26, 1908	244	
Elected during 1908–09	25	
Total		269
Suspended during the year	3	
Resigned " "	7	
Died " "	1	
Total		11
Total members, April 23, 1909		258
Gain in membership during the year		14

FINANCES.

Receipts.

Cash on hand, April 17, 1908	$137.95	
Excursion tickets	124.00	
Dues and initiation fees	1,112.10	
Sales of reprints of Journal	11.60	
Annual banquet	2.50	
Total receipts		$1,388.15

Expenditures.

Banquet	$315.50	
Journal	439.00	
Reprints	11.60	
Excursion	171.75	
Music at excursion	37.50	
Secretary's salary	100.00	
Rent of assembly and committee room	85.00	
Printing, postage and miscellaneous expenses	194.95	
Total expenditures		1,355.30
Cash on hand		$32.85

Respectfully submitted,

George H. Fenkell,
Secretary-Treasurer.

Auditing Committee.

The books of the Secretary-Treasurer have been audited by

Byron E. Parks,
T. F. McCrickett,
Members of Executive Committee.

Association of Engineering Societies.

Vol. XLII. | May, 1909. | No. 5.

PROCEEDINGS.

Engineers' Club of St. Louis.

St. Louis, April 7, 1909. — The 667th meeting of the Engineers' Club of St. Louis was held at the Club Rooms, 3817 Olive Street, on Wednesday evening, April 7, 1909, at 8.30 p.m. President Wall presided. There were present twenty-one members and one visitor.

The minutes of the 666th meeting were read and approved, and the minutes of the 461st meeting of the Executive Committee were read.

The following were elected: E. G. Hooper, member; T. E. Flaherty, associate member.

The President announced the recent deaths of Mr. William Eimbeck, a charter member of the Club, and of Mr. J. W. Schaub. Mr. William H. Bryan was appointed a committee to draw up a memorial to Mr. Eimbeck, and Mr. Edward Flad to draw up a memorial to Mr. Schaub.

On motion of Mr. Bryan, it was voted that the Executive Committee draft and present at the next meeting of the Club an amendment to the By-Laws, with a view to the reinstatement without initiation of members who have resigned while in good standing.

There being no further business, the chairman called upon Mr. S. Bent Russell to present the paper of the evening on "Notes on the Design of Large Filtration Plants." Mr. Russell described the various kinds of sand filtration in use, and presented considerable data on such plants as installed in New Orleans, Columbus, Cincinnati, Hackensack, Harrisburg, Little Falls, and the proposed St. Louis plant. The discussion following the paper was participated in by Messrs. Flad, Wall and Russell.

The Secretary announced that an invitation had been extended by the St. Louis Railway Club to attend a meeting to be held on April 9 at the Southern Hotel, at which a paper on Railway Organization would be presented by Professor Hibbard, of the University of Missouri, and at which there would be a demonstration of the processes of autogenous welding by Messrs. Henderson and White.

Adjournment.

A. S. Langsdorf, *Secretary.*

St. Louis, April 21, 1909. — The 668th meeting of the Engineers' Club of St. Louis was held at the Club Rooms, 3817 Olive Street, on Wednesday evening, April 21. There were present thirty-seven members and five visitors. Mr. S. Bent Russell presided.

The minutes of the 667th meeting were read and approved. The minutes of the 462d meeting of the Executive Committee were read.

The Secretary read an application for membership from Mr. Roy A. Campbell.

The following draft of an amendment to the By-Laws, drawn up by the Executive Committee in accordance with the action taken at the Club meeting of April 7, was then presented:

SECTION 7. *Election, Transfer and Reinstatement of Members.* — Candidates for admission to the Club, or for transfer from the grade of associate member to member, or from junior to member or associate member, shall be proposed by not less than two members or associate members at any meeting of the Club. The proposal shall contain a statement, signed by the candidate, of his age, residence, qualifications for membership or transfer, and that he will conform to the requirements of the Club if elected. The proposal must then be referred to the Executive Committee, and if upon examination they shall find the candidate to be eligible and worthy of membership or transfer, they shall order the question as to his admission to be submitted to the Club for ballot. If there be five votes in the negative, the candidate shall be rejected and shall not again be voted upon for twelve months after such rejection. No entry shall be made on the record of the rejection of any candidate. But if the number of negative votes be less than five, the candidate shall be elected, but shall not be entered on the rolls until he shall have paid the initiation fee and dues for the current year. Any failure to pay the initiation fee and dues within thirty days after the candidate has been notified of his election, except as provided in Section 8, shall work a forfeiture of all rights under said election if the Executive Committee shall so determine. The Executive Committee may transfer to the grades of associate member or junior any member eligible therefor who may make written request for such transfer.

The Executive Committee may, for valid reasons, reinstate any person to membership who has resigned from the Club in good standing. Applicants so reinstated shall not be required to pay the initiation fee required of new members.

On motion of Mr. W. H. Bryan, duly seconded, it was voted that this amendment be balloted upon as provided in Section 14 of the By-Laws.

Messrs. Greensfelder and Henry, on behalf of the Entertainment Committee, described the arrangements made for a trip to the McKinley Bridge site on Saturday afternoon, April 24.

Mr. Curtis Hill, state highway engineer, then presented an interesting illustrated address on "Sources of Revenue and Superintendence of Expenditures upon Highway Work." Mr. Hill traced in an interesting way the development of methods of building and paying for roads, with particular reference to the present situation in the state of Missouri.

The discussion following the paper was participated in by Messrs. Travilla, Bryan, and Woermann.

Upon motion of Mr. Garrett, a unanimous vote of thanks was tendered to Mr. Hill for his courtesy in addressing the Club.

The meeting then adjourned to the adjoining rooms, where refreshments and cigars were served.

A. S. LANGSDORF, *Secretary.*

ST. LOUIS, MAY 5, 1909. — The 669th meeting of the Engineers' Club of St. Louis was held at the Club Rooms, 3817 Olive Street, on

Wednesday evening, May 5, 1909, at 8.30 o'clock. In the absence of the President and Vice-President, the meeting was called to order by the Secretary, who asked for nominations for a temporary chairman. Messrs. A. P. Greensfelder and Edward Flad were nominated, but Mr. Greensfelder withdrew his name, and Mr. Flad was thereupon called to preside.

The minutes of the 668th meeting were read and approved. The minutes of the 463d meeting of the Executive Committee were read. The amended form of Section 7 of the By-Laws, as previously approved by the Executive Committee, was read by the Secretary and was adopted by a unanimous vote.

Mr. William H. Bryan presented for the consideration of the Club a bill now before the state legislature for the regulation of the practise of architecture and for the licensing of architects. At the request of Mr. Bryan the bill was read in full by the Secretary. After some discussion, Mr. Bryan submitted the following resolution:

In the matter of the proposed bill licensing and regulating the practise of architects, and creating a board of examiners of architects, which bill is said to have passed the Senate and to be now in the hands of the Judiciary Committee of the House of Representatives of the state of Missouri,

The Engineers' Club of St. Louis, with a membership of nearly three hundred engineers engaged in the practise of their profession, a large percentage of whom are connected with the designing and installing of the engineering features of buildings, respectfully begs leave to file its protest against the passage of the proposed bill for the following reasons:

1. The examining and licensing of applicants is to be based upon their knowledge (see Section 4) of the construction of buildings, the strength of materials, the sanitary laws applied to buildings and the application of such knowledge and the supervision of the mechanical work on buildings, all of which are strictly engineering questions.

2. Engineers, who have had special training and experience in these matters, are barred from handling buildings, and architects, very few of whom are specially trained in these lines, are the only ones permitted to do so.

3. If it be answered that engineers may take the examination the same as other people, attention is called to the fact that the Examining Board is to be made up of four architects and one member of the faculty of the state university, the latter not necessarily either an architect or engineer. It is respectfully submitted that for examinations along engineering lines the majority of the Board of Examiners should be engineers.

4. Not only would it be improper for a board so constituted to pass upon strictly engineering questions, and to have the power of barring competent engineers, but there is nothing to prevent their going further and extending the examination into branches which have no connection with the safety or sanitation of the building, such, particularly, as the orders of architecture, the design of ornamental fronts, Greek columns, etc.

5. The reference to civil engineers at the end of Section 9 seems to be of no particular effect. When such an engineer plans, designs or supervises the erection of buildings, he is to be considered an architect, subject to the provisions of the act. But such status would not seem to bring him under the provisions of Section 5, which is limited to those who make architecture their principal business. He would not, therefore, be given an original license without examination. On the other hand, the fact that he is a civil engineer gives him no better standing in the matter of original examination than anybody else has, these examinations being open to any one over twenty-five years of age of good moral character.

6. It may be questioned whether this special reference to civil engineers does not make this "class" legislation, as other engineers may also

be competent to design buildings. All engineers are given some training in the design of framed structures and the strength of material, stability of foundations, etc. The mechanical engineer designs the boilers, engines, heating and ventilation and elevators, which are of decided importance as regards both the safety and the sanitation of buildings. The electrical engineer handles electrical current, installs motors, distributes light and power, all of which are important elements in safety.

The Engineers' Club of St. Louis favors the establishment of reasonable regulations covering the safety and sanitation of buildings, and will lend its support to any well-directed effort in that direction. It furthermore believes in limiting such work to the hands of competent parties. It protests, however, against a bill which bars engineers of established competency from such work. It protests further against the absence of engineers on the Board of Examiners.

For these reasons it believes it will be better to defer action until a more fairly drawn bill can be prepared.

On motion of Mr. Layman, seconded by Mr. Greensfelder, it was voted to adopt the resolution, and that a committee of three be appointed by the chair to take up the matter with the proper authorities at Jefferson City. After further discussion Mr. Layman, with the consent of his second, moved to amend the above motion by making the committee consist of three vice-presidents of the Club, with power to edit the resolution as above stated. Amended motion carried. The chairman appointed Messrs. Bryan, Brenneke and Russell.

On motion of Mr. Greensfelder it was voted to extend the thanks of the Club to Mr. Ralph Modjeski, the American Concrete Company, the Myers Construction Company and the United Railways Company for courtesies extended to the Club on the occasion of the visit to the McKinley Bridge on Saturday, April 24.

Mr. M. L. Holman then presented the paper of the evening, "The Water Supply of Ancient Rome." The paper represented the results of a careful study of the figures given by Frontinus in his description of the water supply of ancient Rome. Mr. Holman showed, for instance, that the value of π used by the ancient Romans was 22-7, and that the calculations of the diameters, areas and discharges of orifices of different size are correct to within a small limit, except in one or two cases, where the discrepancies may be due to the errors of the scribes in copying the original manuscript. The paper was followed by an interesting discussion, led by Prof. F. W. Shipley, of the Latin Department of Washington University, who explained some of the reasons for the large number of errors that have crept into the copies of the original manuscript.

The Secretary read a letter from the "Million Population Club" requesting the Engineers' Club to name a representative to confer with the Million Club for the purpose of bringing to the attention of the Board of Freeholders a proposition to advertise the city of St. Louis. No action was taken.

Adjournment.

A. S. Langsdorf, *Secretary.*

Boston Society of Civil Engineers.

Boston, May 19, 1909. — A regular meeting of the Boston Society of Civil Engineers was held at Chipman Hall, Tremont Temple, at eight

o'clock P.M., President George B. Francis in the chair. Eighty-two members and visitors present.

On motion, duly seconded, it was voted to dispense with the reading of the records of the last regular meeting and the special meeting of May 5, inasmuch as they have been printed in full in the May *Bulletin*.

Messrs. Henry B. Alvord, Moses Burpee, John F. Callahan, Jr., Edwin P. Dawley, Ralph W. Emerson, Elmer O. Goodridge, Richard K. Hale, Arthur W. Hodges, Charles A. Mixer, Oren E. Parks and Frank C. Sargent were elected members of the Society, and Mr. James G. Lincoln was elected an associate.

The Secretary read a letter from the Secretary of the American Society of Civil Engineers extending, on behalf of the Board of Direction of that Society, a most cordial invitation to the members of the Boston Society of Civil Engineers to attend the annual convention to be held at Bretton Woods, N. H., July 6 to 9, 1909.

On motion of Mr. Brooks, the thanks of the Society were voted to the Directors of the American Society of Civil Engineers for their courteous invitation and the Secretary was directed to suitably acknowledge the same.

The following vote passed at the last regular meeting was ratified, as required by the By-Laws, thirty-five voting in the affirmative and none in the negative.

Voted, That the Board of Government be authorized to use the Permanent Fund for the purchase and equipment of a house for the Society.

The following amendment to By-Law 10, offered in writing at the last meeting, was adopted by a unanimous vote. Insert in the first paragraph before the word " year " in the sixth and eighth lines the word " fiscal," so that the paragraph shall read:

" New members shall not be liable for the annual dues for the fiscal year in which they are elected, and, if elected after October 1, shall be liable for only one half the annual dues for the ensuing fiscal year.

Mr. Edwin P. Dawley was then introduced and read an interesting paper entitled " The East Side Tunnel and Its Approaches, Providence, R. I." The paper was fully illustrated by lantern slides.

The paper was discussed by the President and Mr. Sampson of the Society, and by Mr. H. L. Ripley, assistant engineer, and Mr. J. A. Droege, division superintendent of the New York, New Haven & Hartford Railroad.

On motion of Mr. Sampson, the thanks of the Society were voted to Mr. Dawley for his courtesy in presenting to the Society so interesting a paper.

Adjourned.

S. E. TINKHAM, *Secretary.*

Civil Engineers' Society of St. Paul.

ST. PAUL, MINN., MAY 10, 1909. — The regular monthly meeting of the Civil Engineers' Society of St. Paul was held in the Society's new club room, on the second floor of the old State Capitol Building, on Mon-

day evening, May 10, with President H. J. Bernier in the chair. There were present fifteen members and one visitor.

The minutes of the previous meeting were read and approved.

It was then moved, seconded and voted that his Excellency John A. Johnson, governor of the state, receive the thanks of the Society for his kindness in giving the Society the use of quarters in the old State Capitol Building, and that he be elected an honorary member.

It was moved, seconded and carried that a committee composed of Messrs. C. L. Annan, A. H. Hogeland, Alfred Jackson and the Secretary be appointed to draw up a suitable obituary of our recently deceased honorary member, Mr. W. A. Truesdell, and that a copy of the same be presented to his family and published in our records and in the JOURNAL OF THE ASSOCIATION OF ENGINEERING SOCIETIES.

A letter thanking the Society for its floral offering and interest taken by the Society's committee, from his widow and daughters, was read and ordered filed.

It was then moved, seconded and voted that the names of Messrs. G. S. Edmonstone, C. A. Hunt, Hew Miller and Alfred H. Wheeler be dropped from the membership rolls of the Society for the non-payment of dues.

It was then moved, seconded and carried that a committee be named to provide outings or excursions for the Society members during the four months of summer vacation. The following were appointed on this committee: Messrs. J. H. Armstrong (chairman), J. D. Du Shane, Oscar Claussen and the Secretary.

The applications of Messrs. Dwight C. Morgan, L. S. Pomroy and Thos. M. Comfort for full members and P. J. McCauley for junior member were presented and read; and it was duly moved, seconded and voted that the Secretary cast the ballot of the Society admitting these gentlemen to membership into the Society as petitioned.

At the conclusion of the business meeting a pleasant and sociable evening in the way of a smoker was participated in, and the meeting was adjourned to Monday evening, October 11, next.

D. F. JÜRGENSEN, *Secretary.*

Utah Society of Engineers.

SALT LAKE CITY, UTAH, MAY 19, 1909. — The address of the evening was made by Mr. Edward Fink, who gave an intensely interesting account of the experiments which led up to the development of the Fink process of smelting, and also described the construction and operation, in detail, of the Fink Smelter now in operation at the Newhouse properties at Garfield, Utah.

Mr. Fink's talk was illustrated by numerous blackboard drawings and sketches showing the mechanical construction of the furnace used in this new process of extracting precious metals from ores. An interesting feature of the new process is the use of powdered coal as fuel. With concentrates containing more than 6 per cent. moisture, a recent slag analysis showed values as follows: 20.3 per cent. iron oxide, 43.6 per cent. silicon

oxide, 15.1 per cent. aluminum oxide, 13.1 per cent. calcium oxide and 0.28 per cent. copper.

Mr. Fink stated that the losses through fuel dust are practically *nil*, and the practice of feeding the ore to the furnace in smaller and finer pieces permits of very rapid smelting. Twin furnaces are employed in each unit, each 9 by 9 ft., and barrel-shaped, and are lined with ordinary fire brick, designed, of course, for the purpose so that they may be keyed in place.

D. McNicol, *Secretary*.

ASSOCIATION
OF
ENGINEERING SOCIETIES.

VOL. XLII. **JUNE, 1909.** No. 6.

PROCEEDINGS.

Boston Society of Civil Engineers.

BOSTON, JUNE 16, 1909. — A regular meeting of the Boston Society of Civil Engineers was held at Chipman Hall, Tremont Temple, at 8 o'clock P.M., President George B. Francis in the chair; forty-five members and visitors present.

The record of the last meeting was read and approved.

Messrs. Robert B. Bellamy, Harold L. Carter, Clifford N. Cochrane, John F. Osborn, Edward H. Rockwell, John B. Russell, Ezekiel C. Sargent, Robert L. Whipple and Harry P. Wilson were elected members of the Society.

Messrs. Otis F. Clapp and Edwin F. Dwelley, the committee appointed to prepare a memoir of Isaac K. Harris, submitted its report, which was read by the Secretary.

On motion of Mr. Barrows, chairman of the Excursion Committee, it was voted unanimously: That the Society express its hearty thanks to the officials of the Springfield Water Department for the privilege recently enjoyed of visiting the new works of the Little River supply, and for the hospitality and kind attention shown on this occasion.

On motion of Mr. Howard it was voted unanimously: That the thanks of the Society be expressed to the officials of the Boston Elevated Railway Company and to the Hugh Nawn Contracting Company for courtesies extended to-day in visiting the new Forest Hills Station; also to the Quincy Market Cold Storage and Warehouse Company for the privilege of inspecting their new cold storage building.

Mr. Henry F. Bryant then read the paper of the evening, entitled, "A High Head Hydro-Electric Development in Vermont." The paper was very fully illustrated by lantern slides. It was discussed by Messrs. Charles T. Main and Harold K. Barrows.

Adjourned.

S. E. TINKHAM, *Secretary.*

WILLIAM EIMBECK.

(See Memoir, page 36, July JOURNAL)

JOURNAL

OF THE

Association of Engineering Societies.

St. Louis. Boston. St. Paul. Montana.
Pacific Coast. Detroit. Louisiana.
Milwaukee. Utah.

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July to December, 1909.

PUBLISHED MONTHLY BY

Fred. Brooks, Secretary of the Board of Managers of the
Association of Engineering Societies.

31 Milk Street, Boston.

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No. 1. JULY.

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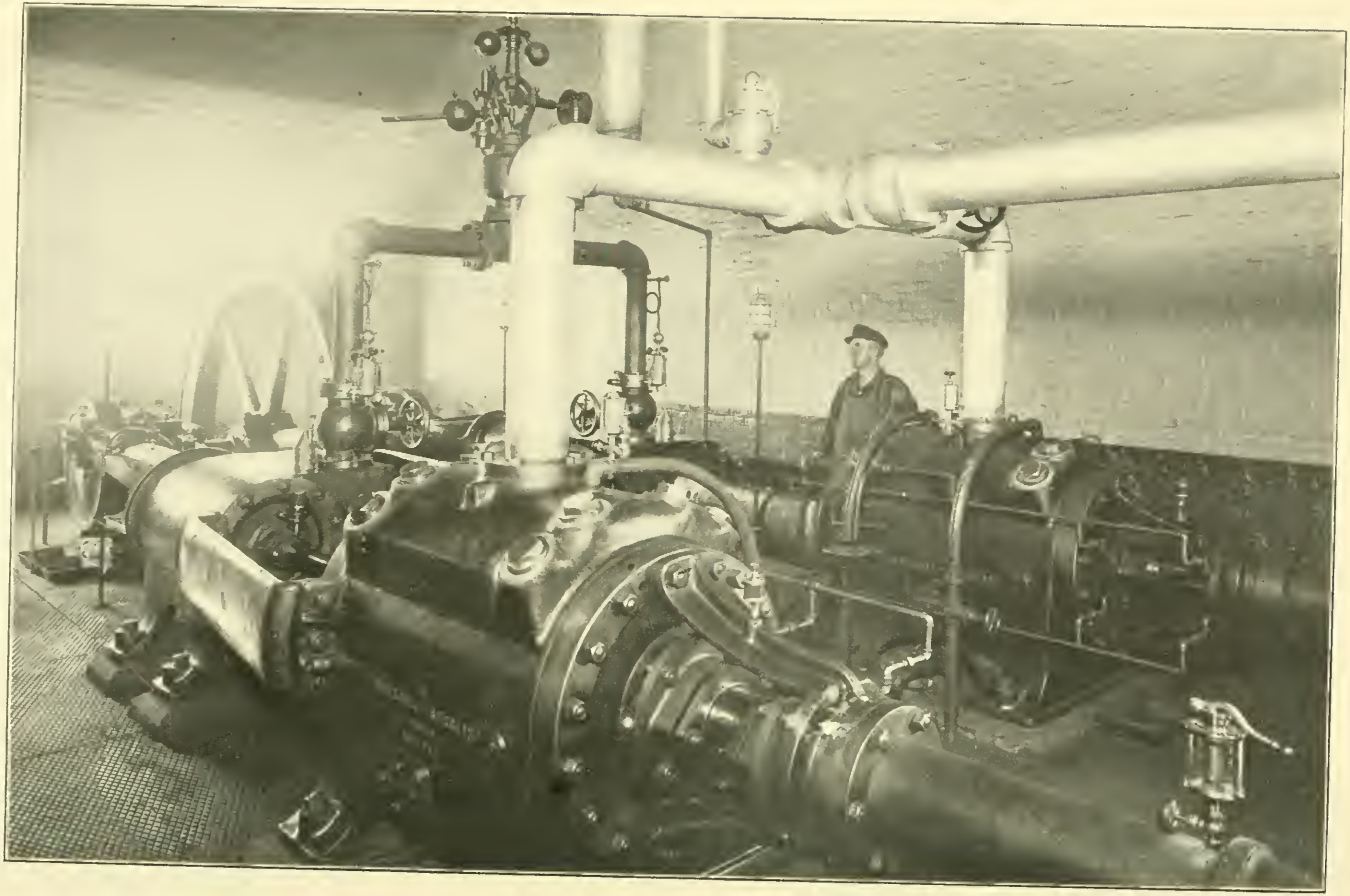
ABBREVIATIONS. — D. = Discussion; I. = Illustrated.
Names of authors are printed in *italics*.



Ingersoll-Sergeant Gas Compressor.

ASSOCIATION OF ENGINEERING SOCIETIES.

Organized 1881.

VOL. XLIII. JULY, 1909. NO. 1.

TEST OF GAS COMPRESSOR NO. 3 OF THE NEW ORLEANS GAS LIGHT COMPANY, SATURDAY, JANUARY 9, 1909.

By W. B. GREGORY, MEMBER LOUISIANA ENGINEERING SOCIETY.

[Read before the Society, March 8, 1909.]

1. *Object of test.*

The object of this test was to determine the mechanical efficiency of the cross-compound single-stage compressor, built by the Ingersoll-Sergeant Drill Company; to determine the values of "n" for the compression curve; and to determine approximately the amount of steam per indicated horse-power hour.

2. *Formulæ.*

The steam indicated horse-power was calculated from the steam indicator cards by the following formula:

$$\frac{P_s l a_s n}{33\,000} = \text{i.h.p.} \qquad 1.$$

The indicated horse-power for the gas compression was calculated in the same way from the gas compression cards.

$$\frac{P_g l a_g n}{33\,000} = \text{Gas i.h.p.} \qquad 2.$$

The cards were taken simultaneously and the ratio of (2) divided by (1) was determined.

3. *Method of performing the test.*

The method of performing the test was to take indicator cards simultaneously from the high pressure and low pressure steam cylinders and the right and left gas compressor cylinders.

Number	Time	Temperatures Gas Entering	Temperatures Gas Leaving	Temperatures Water Entering	Temperatures Water Leaving	Temperatures Room	Steam Pressure	Recording Gauge	Intake Press Inches Water	Discharge Gas Pressure Gauge	Rev. Counter	R.P.M. for 20 min	R.P.M. for Card
1	12:00	75.4	210	82.	83	71	108	118	-1.8		125244		53
2	:20	76.4	218	82	84	77	109	118	-1.8		6405	58	71
3	:40	76.4	211.5	82	88	77.2	113	122	-2.15		7523	55.8	55
4	1:00	77.4	208.5	82	89	79.	113	122	-1.7		8563	52	55
5	:20	77.4	218.5	82	91	79	115	123	-1.8		9713	57.5	57
6	:40	77.9	214	82	90.5	80	105	113	-2.3		130782	53.45	51
7	2:00	77.9	225	82	94.5	79	110	118	-2.3		1851	53.4	52
8	:20	78.9	230	82.1	93.5	81	111.5	120	-2.05		2869	50.9	54
9	40	78.9	218	82.6	88	80.5	104	112	-2.07		3904	51.7	50
10	3:00	78.9	212.4	82.2	88	80.5	101	109	-1.9		4960	52.8	49
11	:20	79.4	208	82.6	88	80.5	100.	108	-2.5		5993	51.6	50
12	:40	80.4	218	81.6	88	80.	101	110	-1.5		7192	59.9	58
13	4:00	79.9	232	80	89	79	106	114	-2.1		8326	56.7	52
14	:20	79.4	223	80.8	89.8	80	97.	105	-3.3		9251	46.2	44
15	:40	79.4	220	80	89.3	79.	102	110	-2.8		140277	51.3	49
16	5:00	79.4	227.8	81	89	79	113	121	-1.0		1550	63.6	68
17	:20	78.4	230	82	90	79	110	118	-1.0		2797	62.3	64
18	:30			82	91.5	79					3649		92
19	:40	77.4	258	82	93.	79	118	126	-2.8		4541	87.2	75
20	6:00	76.9	249	83	89	79	109	120	-2.35	38.5	6285	87.2	80
21	:20	76.4	252	82	92	77	109	121	-2.9	38.7	8017	86.6	90
22	:40	76.4	248	83	91.8	76	110.5	120	-3.4	37.8	9808	89.5	88
23	7:00	76.4	240	81	90.8	76	109.	118	-2.3	34.8	151493	84.2	87
24	:20	76.4	240	81	90.	75	108	118	-3.3	34.8	3175	84.1	86
25	:40	74.4	228	81	90	74	105	117	-0.35	33.9	4820	82.2	74
26	8:00	74.9	214	81	88	75	105	115	- 4	30.3	6271	72.5	78
27	:20	74.4	222	80	87	75	105	117	+1.8	31.9	7647	68.8	68
28	:40	75.4	220	81	87	74	107	115	+1.8	31.3	8827	59.0	59
29	9:00	74.9	220	80	86	73	104	113	+1.3	31.1	9926	54.9	55
30	:20	75.4	218	80	87.5	74	110	119	+2.9	31.4	161048	56.1	54
31	:40	75.4	219	79	86.5	73	103	112	+2.2	29.9	2089	52.1	57
32	10:00	75.4	212	79	86	73	108	116	+3.6	30.1	3124	51.8	46
33	:20	74.4	210	79	86	73	96	108	+3.3	28.9	4080	47.8	32
34	:40	74.4	210	80	87	73	107	115	+4.1	31.2	5087	50.4	44
35	11:00	74.4	206	80	86.5	73	104	115	+2.7	30.5	5949	43.1	41
36	:20	73.9	190	80	85.5	72	116	125	+2.7	25.8	6668	35.9	57
37	:40	73.4	170	79	84	71	105	117	+3.8	20.8	7363	34.8	34
38	12:00	73.9	150	76	82.	72	117	120	+2.8	14.3	7990	31.1	35

COMPRESSOR, JANUARY 9, 1909.

Indicated Horse Power — Steam H.P. Crank	Steam H.P. Head	Steam L.P. Crank	Steam L.P. Head	Steam Total	Gas Right Head	Gas Right Crank	Gas Left Head	Gas Left Crank	Gas Total	Ratio Gas I.H.P./Steam I.H.P.	B.T.U.'s per min. to Jacket Water (Average)	H.P. Equivalent to Jacket Cooling	Gas I.H.P. + J.H.P.	Ratio (Gas I.H.P. + J.H.P.)/Steam I.H.P.
28.7	30.4	529	49.8	161.8	30.0	34.3	31.4	31.1	126.8	.784	231	5.42	132.2	.817
51.1	487	66.5	69.6	235.9	59.0	67.3	46.4	47.8	220.5	.935	460	10.90	231.4	.981
30.9	31.4	51.9	52.2	166.4	34.2	36.3	33.4	32.3	135.2	.813	1183	27.9	164.1	.987
29.6	29.1	51.9	50.7	161.3	33.5	35.0	31.2	33.7	133.4	.826	1281	30.2	163.6	1.013
37.1	35.2	55.8	54.3	182.4	37.2	39.8	35.6	36.1	148.7	.815	1630	38.4	187.1	1.025
28.8	27.2	49.0	48.1	153.1	32.4	34.4	31.0	29.2	127.0	.829	1050	24.8	151.8	.992
29.8	29.8	52.7	52.0	164.3	33.5	36.1	31.6	32.4	133.6	.812	925	21.8	155.4	.945
30.3	31.3	53.6	52.9	168.1	34.6	36.6	33.9	32.9	138.0	.820	1150	27.2	165.2	.983
28.2	27.7	43.2	41.9	141.0	33.0	32.2	30.1	28.7	124.0	.880	1040	24.6	148.6	1.053
25.6	24.2	49.9	45.9	145.6	28.6	28.8	28.2	28.8	114.4	.786	1130	26.7	141.1	.970
26.5	26.1	46.7	40.8	140.1	28.2	30.0	27.8	27.7	113.7	.810	1200	28.3	142.0	1.013
35.8	35.8	59.0	54.3	184.9	34.4	35.6	35.1	36.1	141.2	.765	1340	31.7	172.9	.935
35.3	33.6	57.1	52.9	178.9	36.9	39.0	35.6	37.1	148.6	.830	1640	38.6	187.2	1.046
21.9	22.4	41.0	41.0	126.3	29.9	29.2	30.1	22.3	111.5	.883	1650	39.0	150.5	1.190
25.1	25.8	44.9	44.9	140.7	31.9	32.0	29.0	24.7	117.6	.837	1720	40.6	158.2	1.125
45.8	44.0	67.7	65.2	222.7	46.4	46.1	45.6	43.7	181.8	.818	1460	34.5	216.3	.973
34.9	37.9	57.9	55.1	185.8	36.9	38.2	37.5	37.3	149.9	.807	1460	34.4	184.3	.993
77.6	78.3	94.3	88.7	338.9	70.0	67.6	66.2	68.5	272.3	.804	1750	41.4	313.7	.925
61.8	63.0	74.2	73.3	272.3	50.1	55.1	56.0	57.8	219.0	.805	2050	48.3	267.3	.982
64.8	65.2	75.2	71.3	276.5	54.5	60.0	57.6	60.0	232.1	.840	1110	26.2	258.3	.935
75.9	75.0	89.0	84.5	324.4	63.3	67.5	67.0	71.0	268.8	.829	1840	43.4	312.2	.963
95.0	96.4	67.5	61.2	320.1	63.5	69.0	65.6	68.0	266.1	.832	1610	38.0	304.1	.950
94.5	97.4	53.6	51.6	297.1	56.8	59.6	59.9	65.2	241.5	.814	1790	42.3	283.8	.955
94.5	96.2	55.5	54.1	300.3	59.2	63.3	61.9	64.4	248.8	.829	1640	38.8	287.6	.958
80.4	82.8	43.2	39.6	245.7	47.6	50.6	49.6	50.1	197.9	.806	1640	38.8	236.7	.965
82.0	82.7	40.1	37.3	242.1	47.2	50.3	48.5	50.7	196.7	.816	1290	30.4	227.1	.938
75.5	70.5	31.8	36.0	213.8	42.7	45.9	44.2	46.5	179.3	.839	1290	30.4	209.7	.980
62.6	61.3	28.0	28.2	180.1	36.8	39.4	37.7	38.9	152.8	.847	1090	25.6	178.4	.991
58.6	57.9	26.1	25.5	168.1	33.2	35.1	33.6	35.5	137.4	.817	1120	26.4	163.8	.975
56.0	54.7	26.9	25.3	162.9	33.2	35.2	33.7	34.4	136.5	.838	1370	32.2	168.7	1.033
59.0	58.3	26.3	25.8	169.4	36.7	35.2	36.8	35.4	144.1	.851	1360	32.0	176.1	1.038
44.4	43.2	20.9	20.7	129.2	27.0	29.2	26.1	25.8	108.1	.837	1270	30.0	138.1	1.069
30.9	28.5	14.3	14.4	88.1	18.2	19.4	17.4	17.3	72.3	.821	1370	32.4	104.7	1.187
43.8	41.8	19.2	19.1	123.9	26.6	29.0	24.9	24.6	105.1	.849	1380	32.6	137.7	1.011
41.5	39.3	17.7	19.2	117.7	24.0	24.5	24.3	23.7	97.5	.830	1310	30.9	128.4	1.092
44.9	41.0	28.9	28.3	143.1	31.0	28.6	28.0	26.3	113.9	.796	1080	26.4	140.3	.982
17.8	17.8	12.5	11.5	59.6	0.64	13.3	14.3	12.4	40.6	.681	1040	24.6	65.2	1.093
18.0	18.3	12.9	12.4	61.6	10.8	10.9	11.3	11.1	45.1	.730	1230	29.0	74.1	1.202
							Mean			.820				1.007

Observations were also taken of the revolutions per minute, the temperatures of entering and leaving gas, and of entering and leaving jacket water used for cooling the compressed gas and the gas cylinder stuffing boxes, the time of flow for 200 lbs. of this water, the boiler pressure, and the gas intake and discharge pressures. A revolution counter was read every twenty minutes, and a one-minute observation was taken at the time of obtaining each set of indicator cards. The horse-powers from the cards were obtained by using the one-minute observations of revolutions per minute. Time of water flow and its temperature were read continuously at intervals of about one and one-quarter minutes. Indicator cards, temperatures and all other observations were taken every twenty minutes.

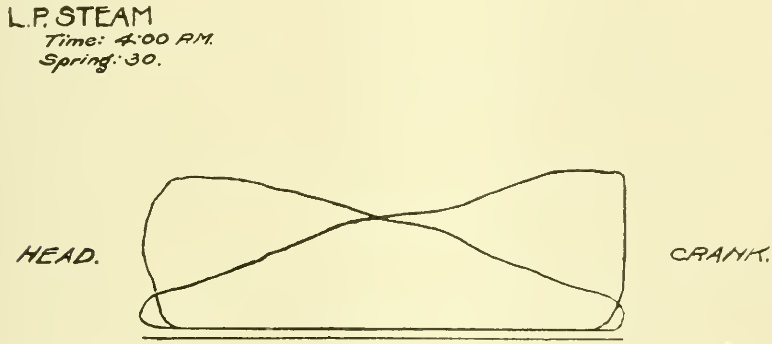
4. *Description of the compressor.*

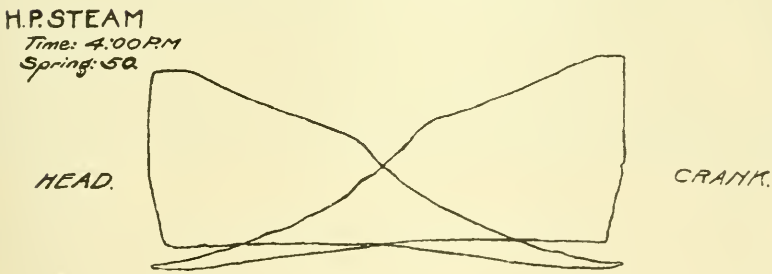
The compressor consists of a horizontal cross-compound steam engine with Meyer slide valves, the cylinders being arranged on opposite sides of a very heavy fly wheel, and a single-stage gas compressor cylinder being built tandem to each steam cylinder on the head end of the steam cylinder. The gas compressor cylinder tandem to the low pressure steam cylinder is called the right gas cylinder, and the other, the left gas cylinder. The high pressure and low pressure steam cylinders are 23 in. and 34 in. respectively in diameter, and the gas compression cylinders are $28\frac{1}{4}$ in. in diameter. The common stroke is 2 ft. The clearance of the left gas cylinder is $\frac{3}{16}$ in. on each end, and in the right gas cylinder it is $\frac{3}{16}$ in. on the head end and $\frac{3}{32}$ in. on the crank end. The head and crank end piston rods of both steam cylinders are $3\frac{3}{16}$ in. in diameter, the crank end piston rods of the gas cylinders are $3\frac{3}{8}$ in. in diameter, and the head and hollow piston rods are $7\frac{1}{4}$ in. in diameter. The gas is admitted through these hollow piston rods, which work through a stuffing box, into the gas pipe entering the hollow piston, and then through suction valves into the cylinder. The delivery is through six automatic valves attached to the periphery at each end of the cylinders. As three-way cocks were used, only one indicator was required for each cylinder. The indicator motions were taken from the cross-heads through wheel-reducing motions. The water for cooling the gas cylinders and stuffing boxes was led through pipes to two barrels on separate scales, and the water delivery pipes were shifted alternately from one to the other. The time for 200 lb. of water to flow was taken with a stop-watch. Not all the water was weighed, but the rate of flow was found at intervals of little more than a minute.

The compressor is used to force gas into the mains to supply outlying districts in the city of New Orleans. The pressure is varied by varying the speed of the engine to suit the demands for gas. This is done by throttling the steam for the high pressure cylinder. The gas compressed is received from large holders 200 or 300 ft. from the compressor. The pressure at the suction intake is approximately atmospheric; the variation is shown in the log. The test lasted from twelve noon to twelve midnight, and the pressures were varied between 10 and 40 lb. per square inch.

5. *Discussion of the indicator cards.*

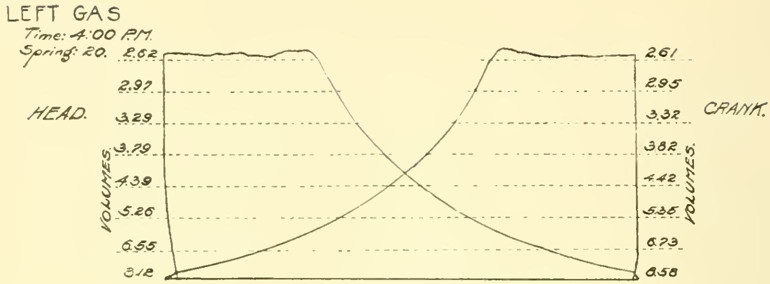
The indicator cards from the steam cylinders show the work given up by the steam to the engine. This work is used in several ways:





1. Gas compression.
2. Heating of gas during compression.
3. Heating jacket water.
4. Friction of machine.

1 and 2 are found from the indicator cards of the gas cylinders.



Compression of a gas, or a mixture of gases, accomplished very slowly, so that the compression is effected without change of temperature, is known as isothermal compression. The curve of compression in that case is an equilateral hyperbola, asymptotic to the lines of zero pressure and zero volume. The equation of the curve is $PV^1 = C$. P and V represent absolute pressure and volume, respectively.

Compression accomplished so rapidly that no heat is extracted from the gas is known as adiabatic compression. The equation of the curve of compression in that case is $PV^n = C$, in which P and V are absolute pressure and volume, respectively, at any point on the curve, and " n " is the ratio of specific heat at constant pressure to that at constant volume for the gas or mixture of gases.

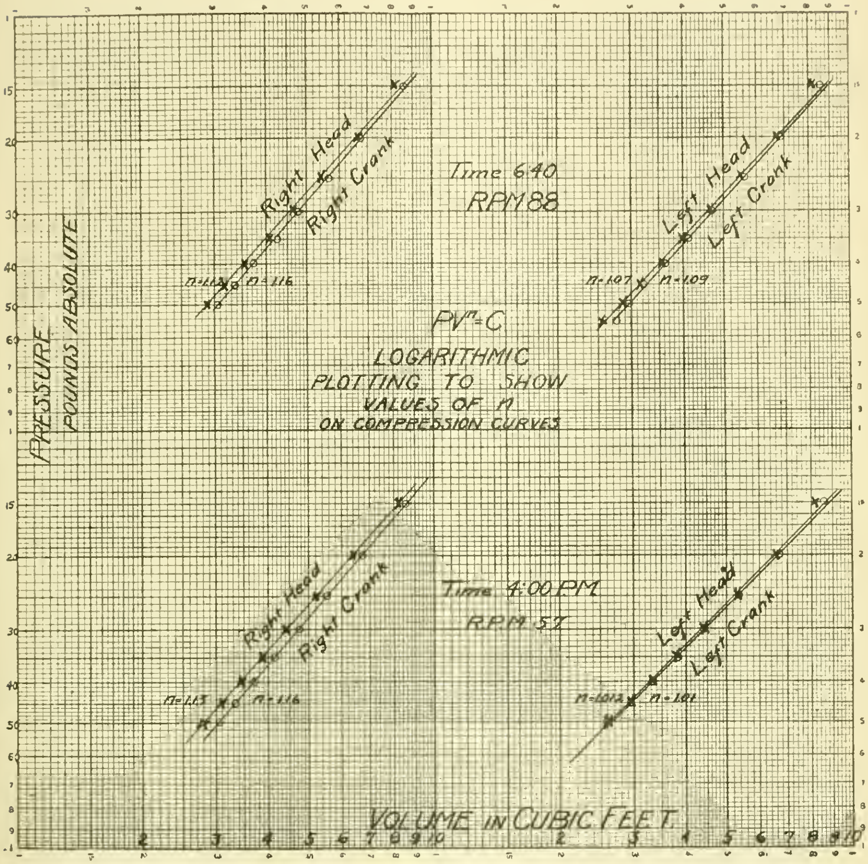
If the analysis of the gas is known, the value of " n " may be computed. The average analysis was given, and the computation below made for theoretical " n."

I. Constituents.	II. Per Cent. Weight.	III. Weight of One Cu. Ft. in Lb.	IV. Weight in One Cu. Ft. of the Mixture. Lb.	V. Ratio $\frac{K_p}{K_v}$	VI. IV × V.
CO_2	2.40	.12267	.00295	1.29	.00381
C_2H_4	9.00	.07809	.00703	1.26	.00886
O	0.50	.08921	.00045	1.41	.000635
CO	31.00	.07807	.0242	1.41	.0341
H	35.20	.00559	.00197	1.41	.00278
CH_4	18.50	.04464	.00827	1.32	.01090
N	3.40	.07831	.00266	1.41	.00375
			.04753		.06484

$$n = \frac{.06484}{.04753} = 1.364$$

In any practical case a part of the heat of compression is given up to the jacket water, and the actual curve of compression lies between the isothermal and adiabatic curves.

Some of the gas cylinder indicator cards were worked up on logarithmic plotting paper, and the actual value of "n" in the

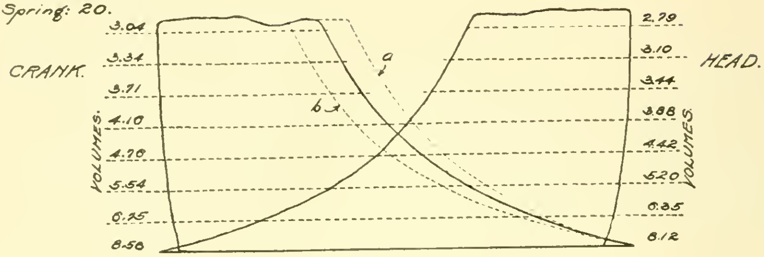


equation $PV^n = C$ was found from these plots. The average values found for "n" were:

R. P. M.	Left Compressor.	Right Compressor.
88	1.080	1.140
57	1.011	1.145

The smaller value of "n" in the left gas compressor as well as the variance of its values at the differing revolutions per minute was due to a leak past the piston in that cylinder. The cylinder had been scored by a broken valve.

RIGHT GAS
Time: 4:00 P.M.
Spring: 20.



On the indicator cards from which the actual "n" was found, the curve of adiabatic compression, $PV^{1.364} = C$, was plotted. This is curve "a." The curve of isothermal compression, $PV^1 = C$, was also plotted. This is curve "b." The area included between the isothermal curve and the actual curve represents the work given up to the gas as heat. This was found to be 10 per cent. of the area of the actual card. The area included between the actual curve and the adiabatic represents the work given up to the jacket as heat, and the friction of rings and rod of compressor cylinder. This amounts to 8.13 per cent. of the area of the actual card.

6. *Water observations.*

Water was circulated around the stuffing boxes of the gas cylinders, and this water was weighed with the jacket water, and the temperature of the mixture was observed. In this way the heat given to the jacket, which was calculated from the water observations, included also a part of the frictional losses in the machine. Thus the sum of the gas indicated horse-power and the water horse-power in the log includes all the work given up by the steam except a part of the frictional losses.

The average range of temperature of the jacket water was only about $7\frac{1}{2}$ degrees. An error of one degree would affect the amount of heat accounted for in heating the jacket water by more than 13 per cent. In reading the water intake and discharge thermometers, slight errors could easily be made, although the thermometers were carefully calibrated and corrections made. It was found that the horse-power shown by the gas compression cards plus the heat energy given up to the jacket was 1.007 times the indicated horse-power from the steam cylinders. This is in part due to the lag in the transfer of heat from the gas cylinder to the jacket water, and in part to the fact that the thermometers could not be read with absolute accuracy, for the reason explained above. It is probable that the friction

unaccounted for amounts to from 5 to 7 per cent. of the steam indicated horse-power.

7. *Volumetric efficiency.*

It is impossible to arrive at reliable results regarding volumetric efficiency except by actual measurements of volume of gas pumped as compared with the displacement of the compressor pistons. Even then if the range of revolutions per minute and pressure pumped against varies widely, as in this test, it will be difficult to select a set of cards that will be representative of average conditions.

The volumetric efficiency as shown by the right gas cylinder cards for 4.00 P.M. is as follows

Crank end	96.0
Head end	93.3
Mean	94.6%

The high volumetric efficiency from the cards of the left-hand gas cylinder is undoubtedly due to leakage past the piston, on account of the scoring of the cylinder previously referred to The results from the left side cards are as follows:

Crank end	102.6
Head end	103.2
Mean	102.9%

If we assume that the leakage in the right gas cylinder was too small to be appreciable, it follows that the leak on the other side amounted to $102.9 - 94.6 = 8.3$ per cent. of the volume of cylinder displacement. This was for atmospheric pressure only. As the piston advances, the leakage increases, and at 50 lb. pressure per square inch, above the atmosphere, the cards show that the volume of gas discharged from the left cylinder is only 90 per cent. of that discharged from the right cylinder, and this in spite of the fact that it started with 108.3 per cent. of the volume of gas shown by the right cylinder at atmospheric pressure.

From these figures the impossibility of accounting for the volumetric efficiency as found by measurements from a gas holder can be realized. Another difficulty is the fact that the temperature of the gas as it enters the cylinder is unknown. The temperature of the gas in the suction pipe was 79.9 degrees fahr., and that of the compressed gas 238 degrees fahr. The gas had to enter through the piston, and as it passed through the valve it undoubtedly was heated considerably. The piston is not water cooled and may become heated to a temperature approximating

that of the compressed gas. This can be seen if we assume the probable mass of iron in the piston and the cooling necessary to raise the temperature of the gas. The cylinder is $28\frac{1}{4}$ in. in diameter. If we assume a disk of cast iron 2 in. thick as representing the mass of the piston, it will contain about 1 250 cu. in., and weigh about 340 lb. The specific heat of cast iron is about 0.13, and the computed specific heat of the gas at constant pressure is 0.325. Now the weight of cast iron times the specific heat of cast iron times the range of temperature through which the iron is cooled is equal to the weight of gas times the specific heat of the gas times the range of temperature through which the gas is heated. If we assume that the gas was heated to a temperature of 200 degrees fahr. from the suction temperature of approximately 80 fahr., the range of temperature for the gas is 120 degrees. Then 340×0.13 (range of temperature for cast iron) $= .4 \times 0.325 \times 120$. From this equation the range of temperature for the iron is found to be 0.35 fahr. This shows that the mass of the piston would only need to be cooled 0.35 of a degree fahr. to heat the gas to 200 fahr.

Now the volume of a gas varies inversely as the absolute temperature. The absolute temperature for the suction gas is $461 + 80 = 541$, and the absolute temperature of the gas in the cylinder at approximately atmospheric pressure is, according to the above assumption, $200 + 461 = 661$. Then $541 \div 661 = 0.818$.

In the left cylinder the loss by leakage has been shown to be 18.3 per cent., so that the volumetric efficiency is reduced to 81.7 per cent. This averaged with 94.6 per cent. for the right cylinder gives a mean of 88.1 per cent.

Correcting for temperatures we have, $0.818 \times 0.881 = 0.721$, or 72.1 per cent.

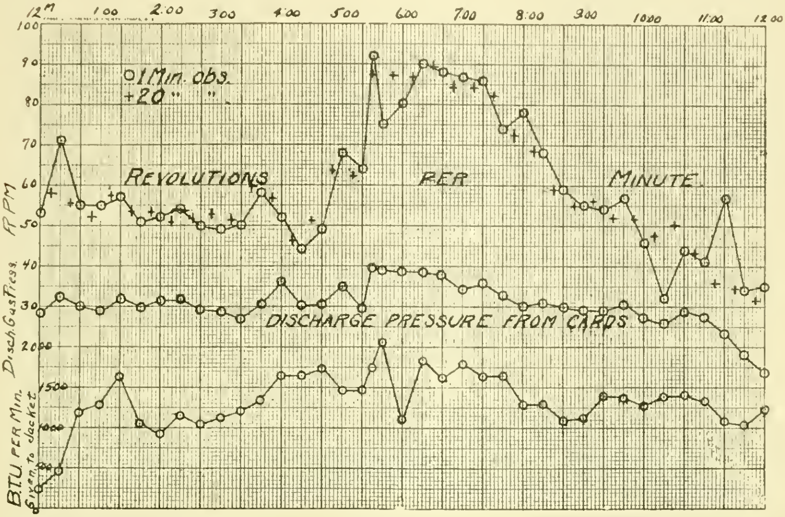
The volumetric efficiency found by actual measurements was about 65 per cent. The above method of computing is, of course, crude and unsatisfactory, as the temperature of the gas that fills the cylinder is unknown.

8. *Steam rate.*

An attempt was made to compute the amount of steam used per i. h. p. hour from the indicator cards taken at 6.40 P.M. While it is easy to determine the volume of steam as shown by the cards, it is known that a large part of the steam is condensed in the cylinders and, therefore, the value of the diagram factor is in doubt. Under the circumstances the results amount only to an intelligent guess. It is believed that the diagram factor was

not far from 0.65, and on this basis the steam per i. h. p. hour amounts to 29.4 lb. It is of interest to note that the builders of the compressor give 28 lb. as the steam rate.

The principal results have been arranged in graphical logs.



Taking into consideration the widely varying conditions and the condition of the compressor, the results are highly satisfactory.

I am greatly indebted to Mr. Jas. M. Robert of the faculty of the College of Technology of Tulane University of Louisiana for valuable assistance in making this test and to the senior class in the mechanical-electrical engineering course for taking observations and for computing the results.

[NOTE. — Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by October 1, 1909, for publication in a subsequent number of the JOURNAL.]

THE PANAMA CANAL.

By Frederic P. Stearns, Member Boston Society of Civil Engineers.

[Read before the Society May 5, 1909.]

President Roosevelt, in December, 1908, appointed a board of seven engineers to accompany William H. Taft, the President-elect, to the Isthmus of Panama to look into the condition of the canal work, and especially to report upon the feasibility and safety of the Gatun Dam.

The party sailed from Charleston, S. C., on the armored cruiser *North Carolina*, on January 25, 1909, and reached the Isthmus four days later. It spent ten days examining the work in progress and the plans and then returned via New Orleans to Washington and there made its report to the President on February 16, 1909.

The primary purpose of this meeting is to give an account of the visit to the Isthmus and the results of observations made during the visit. It is desirable, however, in view of the many criticisms that have appeared in the daily press since November last, to devote a part of the time to discussing the type of canal and replying to a part of these criticisms.

Another reason for devoting a part of the time to a discussion of the type is that many people, including many engineers who have not been to the Isthmus and who have not looked carefully into the question, naturally suppose that a sea-level canal is the best type for that place and that a mistake is being made in constructing a canal with locks.

An ideal sea-level canal, 500 ft. or more in width and of sufficient depth to float, with plenty of water under the keel, the largest steamers, and without locks or other obstructions, is an interesting conception. Such a canal, under the title of "The Straits of Panama," is the subject of Mr. Bunau-Varilla's frequent and lengthy communications, when he is not criticising the plans of others; but those who are not dreamers know that such a canal would make very great and unnecessary drain upon the national treasury and would, before its completion, not only exhaust the patience of the American people and of Congress, but would defer too far into the future the time for passing our navy and the commerce of all nations from one ocean to the other.

Every commission charged with a consideration of the type

of canal has put aside any such impracticable suggestion as a wide sea-level canal without a lock, and has reached the conclusion without dissenting votes that the most practicable sea-level canal would require a lock at its Pacific end and would have a bottom width not exceeding 150 ft. in portions excavated in earth, where the banks would be sloped; and 200 ft. in rock, where the sides below the water level would be nearly vertical.

The large amount of excavation is not the only great problem connected with the construction of the sea-level canal. The Chagres River and many smaller streams which would empty into such a canal must be controlled by dams and diverted by parallel canals on both sides of the main canal before the construction of the latter for a large part of its length could be begun, and these streams would make the construction more difficult throughout substantially the whole length of the canal.

It would be necessary for all time to maintain these diversion canals, which would be very expensive, or after the completion of the sea-level canal to allow the streams to flow into it and produce currents which would be detrimental to navigation.

The lock canal, while it has the admitted disadvantages of locks, so raises the level of the water for nearly the whole distance across the Isthmus as to make it feasible to provide wide channels for navigation at a comparatively moderate expenditure of time and money, and solves in a most satisfactory manner the problem of the floods in the Chagres and other streams, without the construction of any dams in addition to those necessary for canal purposes.

In the comparisons which I will make between the lock canal and the sea-level canal, I will in all cases, unless otherwise stated, refer to the narrow sea-level canal recommended by the majority of the Board of Consulting Engineers in 1906; that is, to the canal that has a bottom width of 150 ft. in earth and 200 ft. in rock.

Colonel Goethals, the chairman and chief engineer of the Isthmian Canal Commission, has recently made careful estimates of the cost of the lock type of canal now under construction, including several changes from the original plan, such as increased size of the locks, the widening of the canal from a minimum of 200 ft. to a minimum of 300 ft., and the moving of the locks at the Pacific end of the canal back several miles from the coast, where they can be more easily defended.

On account of these changes, and for other reasons which will not be mentioned now, the estimated cost of the canal has

been greatly increased above the original estimate and is now placed at $375 000 000. It is estimated that this sum will be diminished $15 000 000 by money returned to the United States Treasury, but for the present purposes I will assume $375 000 000 as the total outgo for the acquisition and construction of the lock canal.

His corresponding estimate of the cost of the sea-level canal is $563 000 000.

According to these estimates, which are based on more complete information, both as to the quantities of work and the cost of doing the work, than any previous estimates, the narrow sea-level canal would cost $188 000 000 more than the wider lock canal.

These figures do not include the interest on the money expended during the construction of the work, because such interest does not come out of the funds provided for the construction of the canal, but it does have to be paid by the people of the United States and is no less a burden than a similar sum paid for construction.

The sea-level canal would require six years longer for its construction than the lock canal and during this additional six years the interest account, on the basis of 3 per cent. annually, would be $93 000 000.

The difference in the estimated cost, therefore, including interest during construction, is $281 000 000, and the corresponding difference in the fixed charges, reckoned upon a 3 per cent. basis, would be $8 400 000 annually.

In comparing the two types of canal from the standpoint of navigation, I believe that the advantages of the wider channels of the lock type of canal much more than offset the disadvantages of the locks, and that the lock canal will permit ships to pass from ocean to ocean with greater safety than the sea-level canal, and have a greater capacity for traffic.

The time required for ships to go from ocean to ocean varies with the size of the ship and other conditions, but will be approximately 12 hr. with either the sea-level or the lock canal. There would be a difference of an hour or two in favor of the sea-level canal with a small traffic, and a corresponding advantage for the lock canal with a large traffic.

This relative difference in time with different amounts of traffic may need explanation. In a narrow canal it is necessary to follow the precedent furnished by the Suez Canal, where, when two ships are to pass one another, one is made fast at a mooring place and the other passes at half speed.

A theoretical investigation shows that if one ship only passes another made fast, the number of stops in the passage of the canal varies as the square of the number of ships passing in a given time; for example, if four ships passing through the canal in a day require on an average one stop per ship, eight ships per day passing would require four stops per ship; and sixteen ships, sixteen stops per ship.

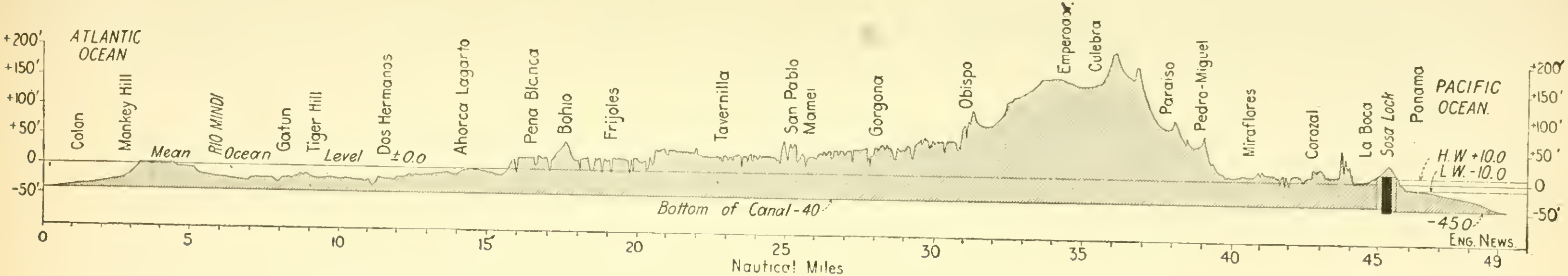
In practice better results are obtained by having two or more ships pass in succession the one made fast, but increasing traffic necessarily increases the time required to pass through a canal which is so narrow as to require tying up to permit the passing of ships, and finally, the delays due to stops become so great as to limit the capacity of the canal, just as the capacity of a single track railroad with occasional turnouts is limited.

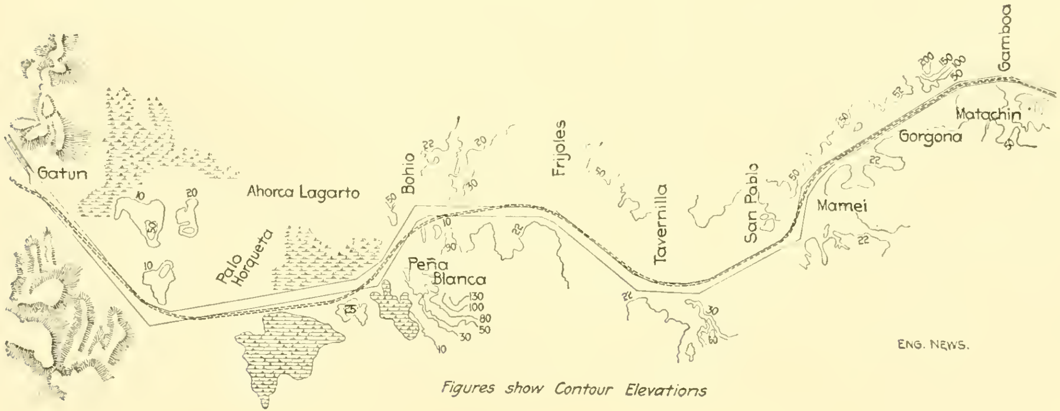
The difference in the time required to pass through the canal is not enough to have any important bearing upon the selection of the type, and we may revert to the more important questions of safety of transit and capacity of canal; but before taking up these questions I will describe briefly the design of the lock canal, as it is now planned, and compare it with the sea-level canal recommended by the majority of the Board of Consulting Engineers of 1906.

Beginning the description at the Atlantic end of the canal, the first 4½ miles are a dredged channel in Limon Bay, which is to be protected by a very extensive breakwater located at its entrance. This channel is to be 500 ft. in width and is to be continued with the same width 2½ miles further inland to the locks required to raise and lower vessels into and from the great lake which will be created by the Gatun Dam.

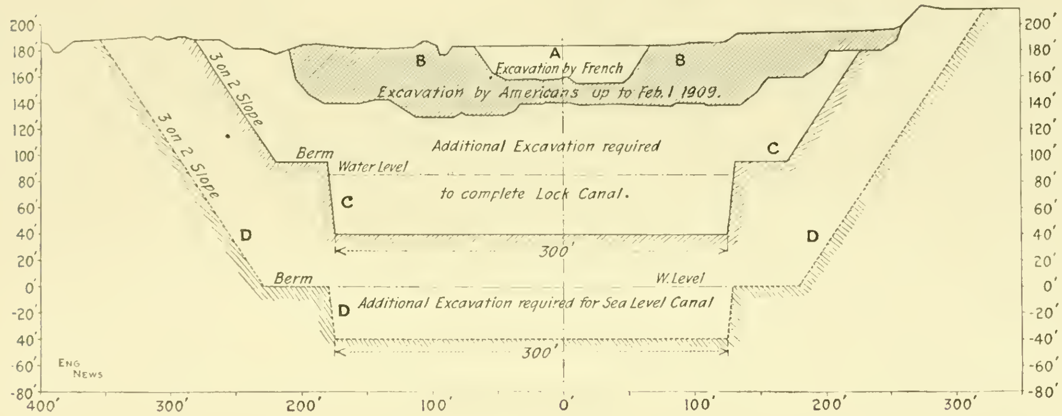
The surface of the lake is to be 85 ft. above the sea level, and ships will be raised to and lowered from this height by passing through three locks of equal lift, each 1 000 ft. long by 110 ft. in width, and constructed in duplicate so that if one set should be out of order the other can be used.

From the locks at Gatun to Obispo, a distance of 23 miles, or more than half of the distance across the Isthmus, ships will have the benefit of lake navigation. The depth of water over the low land near the dam will be from 70 to 75 ft., and nowhere in the 23 miles is the depth to the bed of the river less than 45 ft. The deep channel of the river, however, follows a somewhat tortuous course, but only a small amount of excavation is required in the upper portion of the lake to create channels on straight courses not less than 500 ft. in width at the extreme upper end, and 1 000 ft. wide at points farther down.

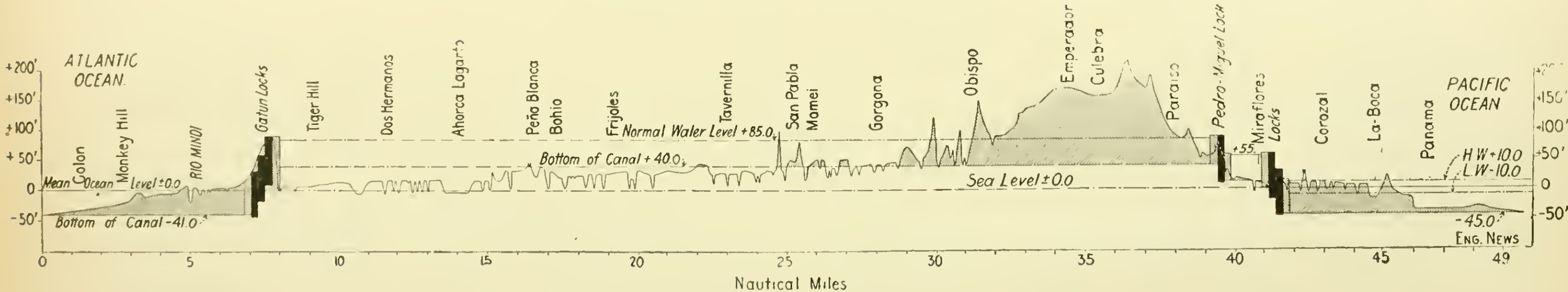




Figures show Contour Elevations



A
B
B
Excavation by French
Excavation by Americans up to Feb. 1 1909.
3 on 2 Slope
3 on 2 Slope
Berm
Water Level
Additional Excavation required
to complete Lock Canal.
C
C
D
D
D
300'
Berm
W. Level
Additional Excavation required for Sea Level Canal
300'
Eng News
200' 180' 160' 140' 120' 100' 80' 60' 40' 20' 0' -20' -40' -60' -80'
400' 300' 200' 100' 0' 100' 200' 300'



ATLANTIC OCEAN
PACIFIC OCEAN
Colon
Monkey Hill
RIO MINDI
Gatun Locks
Tiger Hill
Dos Hermanos
Ahorca Lagarto
Peña Blanca
Bohio
Frijoles
Tavernilla
San Pabla
Mamei
Gorgona
Obispo
Emperador
Culebra
Paraiso
Pedro-Miguel Lock
Miraflores Locks
Corozal
La-Boca
Panama
Mean Ocean Level ±0.0
Bottom of Canal -41.0
Normal Water Level +85.0
Bottom of Canal +40.0
Sea Level ±0.0
+55
H W +10.0
L W -10.0
-45.0
Eng. News
+200' +150' +100' +50' 0 -50'
0 5 10 15 20 25 30 35 40 45 49
Nautical Miles

The next 8 miles of canal pass through the Culebra Cut to the Pedro Miguel Lock, and here in the deeper cutting the canal is to be 300 ft. wide and 45 ft. deep. At Pedro Miguel there are to be twin locks having a single lift, and ships passing towards the Pacific will be lowered at these locks about 30 ft. into a small lake, through which they will pass for about a mile and a half to twin double lift locks at Miraflores, about 4 miles from the shore, and there be lowered into a channel 500 ft. wide extending to deep water in Panama Bay.

The sea-level canal has a channel with a 500-ft. bottom width in Limon Bay and of 300-ft. bottom width in Panama Bay, but for the whole distance across the Isthmus between the shore lines it has bottom widths of 150 ft. in earth and 200 ft. in rock, as already stated.

There is another material difference between the two canals. The sea-level canal follows a curving course for 19 miles out of the 40 miles from shore to shore, or, in other words, for substantially half its length. On the lock canal curved channels are avoided entirely, and changes in direction are made by large widenings at points of intersection. The lock canal, therefore, follows the precedent set in harbor engineering generally and in the canals connecting the great lakes.

The navigation through the 23 miles of Gatun Lake may be best understood by comparing it with the navigation in the important harbors of the country. It would be similar to the navigation through the 10 miles of Boston harbor, extending from the Graves up to the city, except that the channel depths at the Isthmus will be much greater than in Boston harbor, and there will be an absence of currents.

What would the navigation interests in Boston say were it proposed to substitute for such channels as now exist a canal curving for half its length and having a bottom width of 150 ft.?

The passage of the locks may seem a matter of much difficulty to people who are not acquainted with their operation. It has, however, been shown to be a simple matter by the experience at the St. Mary's Falls Canal, where a traffic greater than that which passes through any other canal in the world passes through its locks without accident or delay.

It is easy to see that there will be less difficulty in taking ships into the locks at Panama than into the docks which they usually enter, because the very long piers at the approach to the locks are in the line of the course of a ship, and it is not necessary to turn the ship at right angles to its course in order that it may come alongside of the pier.

At the locks there will be no strong currents such as those that interfere with the docking of ships on the Hudson River front in New York, and it is also true at Panama that the prevailing winds are in the direction of the length of the locks.

When a ship is in the lock it is raised or lowered without difficulty, and the movement into the next lock is only a repetition of the first operation.

There is much statistical material relating to the operation of locks and canals, and it shows clearly that injury to vessels occurs from the grounding or sinking of the vessel in the canals, and does not occur when they are moving slowly into and out of the locks. The statistics show that with wider channels such accidents are less likely to occur.

The Suez Canal in 1886 had a bottom width of 72 ft. and a depth of 26 ft., and the records show that in that year 188 ships, equal to 6.1 per cent. of the whole number, grounded while passing through the canal. In 1900, after the canal had been enlarged, the number of ships grounding was 65, equal to 1.9 per cent. of the whole number for the year. Further widening and deepening of this canal are now in progress.

In the wider channels between lakes Superior and Huron connected with the St. Mary's Falls Canal, although the traffic is several times greater than on the Suez Canal, the percentage of groundings is about one nineteenth of the percentage in the Suez Canal, or about one fifth of such percentage, after making due allowance for the difference in the length of the channels.

It is obvious that the wide channels of the lock canal will have a greater capacity for traffic than the narrow channels of the sea-level canal, and it is, therefore, necessary to make the comparisons only between the locks of the lock canal and the channels of the sea-level canal.

Careful computations made by engineers who have had long experience at the St. Mary's Falls Canal show that the capacity of the locks at Panama will be not less than 80 000 000 tons annually. This is six times the tonnage which passes through the Suez Canal and seventeen times the tonnage passing in and out of Boston harbor to and from foreign ports. In all of these statements, the traffic in both directions is included. So great a traffic could not be passed through the narrow sea-level canal.*

* One of the official publications relating to the Suez Canal gives the details of movements of ships in the canal on the 3d of January, 1908. The movements were substantially equivalent to eleven ships passing the whole length of the canal in a southerly direction, and seven ships passing

The tonnage through the Suez Canal increased in the 37 years from 1870 to 1907 somewhat uniformly from a very small beginning to 15 000 000 tons annually. Unless there is a greater traffic through the Panama Canal than through that at Suez, the capacity of the lock canal will be sufficient to meet all requirements for a very long time in the future — very likely for a century or more.

I have attempted to tell you in a summary way the salient points of difference between a lock canal and a sea-level canal: how even the narrow sea-level canal will cost, by the latest estimates, including interest during construction, $281 000 000 more than a lock canal; that it will require an additional six years to make the sea-level canal available for use; that the lock canal will be safer for the ships passing through it and have a greater capacity for traffic than the sea-level canal.

These are the main reasons why the lock canal is preferable to the proposed sea-level canal, and a wider sea-level canal would require still more time and money.

There has been, however, so much space given in the press, especially in New York, to criticisms of the type of canal now under construction that I will notice a few of the principal points which have been urged against this type. It is stated:

(1) That the Gatun Dam is to be built on permeable and unstable foundations and will, therefore, be unsafe.

(2) That the estimated cost of the lock canal is so far above the original estimate that it is nearly the same as the cost of the sea-level canal, so that the cost is not now an argument against a sea-level canal.

(3) That so much more rapid progress than was anticipated has been made in excavating the canal that the sea-level canal can be completed nearly as soon as a lock canal.

(4) That the size of the locks will limit for all time the size of the ships which can pass through the lock canal.

(5) That earthquakes may destroy the dams, locks and regulating works of the lock canal and interfere with the operation of the gates.

In answering the criticisms of the foundations of the Gatun Dam, I cannot do better than to ask you to make a comparison

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in a northerly direction, making a total of eighteen ships. The tonnage of these ships is not given, but assuming them to be equivalent to the average for the year, they would represent a total of 22 000 000 tons annually, or about one fourth of the capacity of the lock canal at Panama. The total number of stops to enable one ship to pass another was 1.7 per ship, and the length of a stop averaged about 1 hour.

of the weight of authority that pronounces in favor of and against the sufficiency of the foundations.

The board of engineers who recently visited the Isthmus included in its number, in addition to the speakers of this evening, our fellow-member, Mr. John R. Freeman, whose absence to-night I regret. It is unnecessary to state to the members of this Society, who know so well his eminence as a hydraulic engineer, that he is amply qualified to give a sound opinion upon this question.

Other members of the board, not personally known to many of you, who stand at the head of the list as designers and constructors of dams, are Mr. Arthur P. Davis and Mr. James D. Schuyler. Mr. Davis, as the chief engineer of the Reclamation Service, has had occasion to take part in the design, construction and maintenance of more dams of nearly all types than any other engineer in the country.

Mr. Schuyler has built great masonry dams, but his specialty is the construction of high earth dams, built by the hydraulic fill process. He has written valuable treatises on dam construction, and contributed very valuable papers on the subject to the American Society of Civil Engineers.

Mr. Isham Randolph, another member of the Board, is best known from his position as chief engineer of the great Chicago drainage and ship canal. In connection with the original construction and later in the extension of the canal for the development of power, he has had occasion to build extensive dams and regulating works, and he is fully qualified to give a sound opinion on dam construction.

In addition to the members of the recent Board, Mr. Alfred Noble, an engineer at the head of his profession, who has had much experience in the design, construction and operation of canals, and who has been associated with extensive dam construction, and Mr. Benjamin Harrod, whose opinion is of especial value because of his twenty-six-year connection with levee construction on the Mississippi River, have testified to the safety of the Gatun Dam.

Last but not least I will mention the engineers in charge of the work on the Isthmus, who are intimately acquainted with the ground on which the dam is to rest and with the results of the investigations of the site, and they believe the foundations and the dam to be entirely safe, both the present chief engineer, Colonel Goethals, and his predecessor, Mr. John F. Stevens, having testified to this effect.

Those who have made the strongest assertions that the dam would not be safe, have been given the most space in the public

press and have done the most to cause uneasiness in the mind of the public are in some cases not civil engineers, and in other cases they are civil engineers whose experience has not included hydraulic work or dam construction. As a rule, they have had some project of their own, and seek to advance their own project by denouncing the various features of the lock type of canal.

There are a few others whose opinions should have value who oppose the construction of the dam, but the evidence as a whole is overwhelmingly in favor of the safety of the dam. Those who criticise the foundations of the dam refer in their remarks to the portions of the foundation where gorges 200 ft. or more in depth were at some time in the past eroded in the rock and subsequently filled with deposits of alluvial material, generally of a clayey character.

The alluvial material has been thoroughly investigated by test pits and borings made under the direction of Mr. Caleb Mills Saville, a member of our Society, whom many of you know well.

Your attention is especially called to a pit sunk under his direction in the middle of one of these alluvial deposits to a depth of 90 ft. below the surface of the ground and 80 ft. below sea level. The first 36 ft. was excavated in a sandy clay which was so nearly impermeable that only from 20 000 to 25 000 gallons of water per day had to be pumped from the pit to keep it dry. Those of you who are connected with water-works construction will realize what a very small flow this quantity of water represents.

In sinking the pit the remaining 54 ft., no additional water was encountered, showing that the material below the sandy clay was impervious.

I will not weary you with other details, but will state that the investigations prove clearly the satisfactory character of the foundations as regards watertightness and stability. It is of course recognized that clay has not the same degree of stability as sand and gravel, but by spreading the base of the embankment, stability can be secured, and this has been done in the present designs.

The high earth dams built in the West have generally slopes of 3 horizontal to 1 vertical, or steeper slopes. A dam at Gatun with 3 to 1 slopes and the usual elevation above water level would have a base about 600 ft. thick at sea level, while the design which has been adopted has a base of 2 100 ft. in thickness.

Those who state that the great increase in the present estimated cost of the lock canal above the original estimate brings its cost substantially as high as that of a sea-level canal

use the original estimate for the sea-level canal without making additions corresponding to those made in increasing the estimate of the lock canal.

With some exceptions, the same causes which have operated to increase the estimated cost of the lock canal have also operated to increase the estimated cost of the sea-level canal, and there is no better basis for obtaining the relative cost of the two than that furnished by the recent estimates of Colonel Goethals. One has only to look at the relative profiles of the required excavation of the lock and sea-level canal to appreciate how much more excavation is required for the latter.

The third criticism, that much more rapid progress than was anticipated has been made in excavating the lock canal, and that with such rapid progress in excavation it would not take many years to excavate the additional amount of material required for the completion of the sea-level canal, fails to take into account the effect upon the speed of excavation of the Chagres River and other streams, which would enter the canal at points far above sea level.

The Chagres River, where it first meets the line of the canal, when at its ordinary height, is 45 ft. above sea level. On one occasion during our recent visit, there was a flood which raised its level at this point 22 ft., or to 67 ft. above sea level. Much higher floods have occurred.

The bottom of the Culebra Cut in the lock canal as planned is only 5 ft. lower than the ordinary level of the Chagres River at the point mentioned. At the time of the flood nine steam shovels were excavating for the canal channel alongside the Chagres River, some of them behind dikes and others opposite portions of the river somewhat further down stream where the ordinary water surface was below the level of the bottom of the canal. Even under such conditions, these nine shovels were put out of commission for a time.

The bottom of the sea-level canal would be 85 ft. lower than that of the lock canal, and it is inconceivable that any considerable amount of excavation could be done either by steam shovels or dredges on the 13-mile stretch of canal from Bohio, where the river is at sea level, to Obispo, where it is 45 ft. above sea level, in advance of the control of the Chagres River and its tributaries by the construction of the Gamboa and other dams, and by diversion channels on both sides of the canal, extending at least to tide water in the river.

The only practicable way to build the dam proposed, in

connection with the sea-level canal at Gamboa, is to first provide a diversion channel, excavated in rock, through which the Chagres River may flow during the construction of the main dam, this channel to be subsequently closed by the construction of a masonry dam with the necessary regulating works.

In such a diversion channel it would be necessary to build a considerable amount of preparatory masonry work before diverting the river in order to facilitate the subsequent construction of the masonry dam. This plan is being followed at Gatun, where a channel 300 ft. in width has been excavated, and where the laying of the concrete has recently been begun.

It will require more than three years, probably three and a half years, from the time that Congress authorized the construction of the Gatun Dam before the Chagres River will be diverted through the diversion channel. The required diversion channel at Gamboa is longer and deeper than that at Gatun, so that its completion would require not less than three or four years.

The next step at Gamboa, after the diversion of the river, would be the excavation through porous earth to bed rock, a depth of about 60 ft. below the river bed. The proposed dam at this point would be carried to 190 ft. above its base, and, if built of masonry, both the excavation and the structure would be much like the Wachusett Dam at Clinton, except that the Gamboa Dam is much longer and would contain much more masonry.

The dam at Clinton required 5 years for its construction after the diversion channel had been provided, and this is not too long a time to reckon upon for the Gamboa Dam, which would make a total of from 8 to 9 years for the construction of the diversion channel and the dam.

During this period all other diversion channels and dams required by the sea-level canal could be constructed, but it is only after this period of 8 years that satisfactory progress could be made in excavating the canal between Bohio and Obispo.

There need be no cessation of work in the Culebra Cut for the construction of the sea-level canal if a sufficient dam were to be provided to prevent the Chagres River from entering the cut at its northerly end and sufficient pumping machinery were to be provided to keep the cut free from water when it became too low to drain by gravity, but the excavation from low levels would be greatly retarded because the material could not readily be hauled out except at the Pacific end, and the cut would become so narrow that the number of steam shovels and tracks would be restricted.

Believing that the lock canal can be completed in less than 6 years, that the Gamboa diversion channel and dam would require 8 or 9 years for their completion, and that the bulk of the excavation for the 13 miles from Bohio to Obispo would have to be made after the completion of the dam, I am firmly of the opinion that 6 years is the least additional time which should be allowed for the sea-level canal.

The criticism that the size of the locks would limit for all time the size of the ships which can pass through the canal is not warranted. It now seems highly improbable that any war ships or any commercial ships which will require to pass through the Panama Canal will be constructed in the next 25 or 50 years of a size which will not pass through the mammoth locks now under construction, but if the size of ships should continue to grow as it has for many years in the past, it would be feasible to construct larger locks to accommodate them at a small fraction of the additional cost of the sea-level canal; or, if it should be found necessary at some time in the future to dispense with locks, the lock canal can be transformed by widening and deepening, and without interrupting traffic, into a wide and deep sea-level canal. This view was accepted by the thirteen members of the Board of Consulting Engineers of 1905–1906 without a dissenting vote.

The interest on the excess cost of constructing a narrow sea-level canal at the present time would in 40 or 50 years pay for the cost of such transformation to a sea-level canal having a minimum width of 500 ft. and a depth of 45 ft.

The criticism relating to the effect of earthquakes on the dams, locks and regulating works of the lock canal is a groundless one, in so far as it affects the type of canal, because the sea-level canal also has dams, locks and regulating works.

There is nothing in the written history of the Isthmus to indicate that severe earthquakes have occurred, and the masonry of old churches, including the flat masonry arch which is still standing in one of them from 150 to 200 years old, furnishes strong evidence that no severe earthquakes have occurred.

The masonry of these churches, built of rubble and lime mortar, has little stability in comparison with lock walls built of Portland cement concrete. These lock walls are extremely massive structures, some of them being as much as 60 ft. in thickness.

At the time of the San Francisco earthquake, the fault line where the movement was greatest passed through and near several high earth and masonry dams when the reservoirs were sub-

stantially full of water without doing any serious injury. There is no reason to expect different results at the Isthmus, even if an earthquake as severe as that at San Francisco should occur.

It is annoying, especially to those who are working with the utmost energy in the tropics to construct the canal which has been authorized and directed by Congress, to have this constant fire of criticism of the work which they are doing and of the type of canal which they believe is the proper type to be used at the Isthmus.

There is no question but what the lock type of canal is to be built at Panama.

I cannot do better in closing than to quote from President Taft's recent answer to the Panama Canal critics. After stating that the lock type of canal will cost less, require less time for construction and be a safer canal than the proposed sea-level canal, he concludes in these words:

"For these reasons the administration is proceeding to construct the canal on the type authorized and directed by Congress, and the criticisms of gentlemen who predicate all their arguments on theory and not upon practical tests, who institute comparisons between the present type of canal and the sea-level type of 300 to 600 ft. in width that never has been or 'will be on sea or land,' cannot disturb the even tenor of those charged with the responsibility of constructing the canal, and will only continue to afford to persons who do not understand the situation and are not familiar with the history of the canal and of the various plans proposed for the canal, an unfounded sensation of regret and alarm that the government is pursuing a foolish and senseless course. Meantime the canal will be built and completed on or before the 1st of January, 1915, and those who are now its severest critics will be glad to have their authorship of recent articles forgotten."

[NOTE. — Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by October 1, 1909, for publication in a subsequent number of the JOURNAL.]

LOCATION OF PIPES AND CONDUITS FOR PUBLIC SERVICE CORPORATIONS.

By Lewis M. Hastings, Member Boston Society of Civil Engineers.

[Read before the Society, February 10, 1909.]

The importance of suitable locations for pipes and conduits in the public highways of a modern city is becoming more fully realized by city officials as the number of such locations applied for increases. With this incidentally comes the necessity for preserving in some convenient form for future use the records of location already granted and the positions of such structures as they may be uncovered and located from time to time. In many cities great confusion and needless expense have been caused in the construction of public work by lack of knowledge or faulty records of the work already placed in the public streets.

In Cambridge, very much of the responsibility for the proper location of these structures is placed upon the city engineer, as is shown by the general provisions of Section 2 of the city ordinances relating to the engineering department, which follows:

Engineering.

"Section 2. The city engineer shall exercise a general supervision of all matters within said department; he shall be consulted in relation to public improvements of every kind where the advice of a civil engineer would be of service. He shall have the charge of all plans of streets, drains, sewers and structures of every kind not especially belonging to other departments, and shall keep the same properly classified and indexed, and he may make such rules and regulations concerning the taking of plans from his office as he may deem necessary to insure their safety."

In locating sewers in the city, somewhat large powers are given to the city engineer, as will be seen from the following extract from the ordinance relating to sewers, Section 2.

Sewers. Chapter 23.

"Section 2. Whenever any street is opened for the laying of pipes for water, gas or other purposes, or for the prosecution of any work of construction, such laying of pipes and the work connected therewith, such work of construction, shall be so

executed as not to obstruct, in any way, the course, capacity or construction of a common sewer, and whenever pipes for any purpose or any work of construction are found to exist at such a depth or in such location as to interfere with any existing sewer or with the building of any common sewer of the required size and at the proper depth and grades, the department, corporation or person maintaining the same shall, upon notice thereof, at once remove, change or alter said pipe or pipes or other works in such a manner as the city engineer may direct. If such department, corporation or person neglects to comply immediately with the terms of such notification, the city engineer may make such removal, change or alteration, and the cost thereof shall be paid by such department, corporation or persons."

While this section may sound somewhat arbitrary, it has, in fact, been found of very great service in securing the proper locations for sewers in overcrowded streets, and as a matter of fact, the extreme power given to the city engineer by this ordinance has never, I think, been exercised, all the corporations and departments to which it applies recognizing its necessity and acquiescing in its provisions. In this way the moral effect of the ordinance has been useful.

That specific location of the structures of the public service corporations might be more definitely determined before construction was begun, and records of the location of structures as actually built obtained, the following section of an ordinance relating to streets was passed.

Streets.

"No gas pipe, water pipe, sewer conduit, street railway track, pole nor any other structure, except wires, shall be placed beneath, upon or above any public street or way except upon a location and at a grade approved by the city engineer or authorized by the board of aldermen. Within sixty days after the completion of the work so approved or authorized, a final plan showing accurately in detail the lines, grades and construction of the work as finished shall be filed in the office of the city engineer. If required by the city engineer, a preliminary plan showing the proposed location and grade of the structure shall first be filed in his office.

"Any person violating the foregoing provisions shall be subject to a penalty of $20 for each offense and shall remove any structure placed contrary to the provisions of this section if required so to do by the city engineer, and upon failure to do so

the city engineer may make such removal or change and the cost thereof shall be paid to the city by the person or department owning or controlling the structure."

Subject to the general provisions of the above ordinances the corporations desiring locations in the city streets first petition the board of aldermen for such locations, filing with the petition a preliminary plan showing the general location desired, which has been prepared after consultation with the city engineer and agreement upon the general location. This is referred to the committee on highways, who give hearings and consider the matter more or less carefully and make such report as seems for the public interest.

If the report is favorable an order is reported granting the location.

If the location applied for is for a street railway track, the order granting to the West End Street Railway Company, who still own the track and real estate leased to the Boston Elevated Railway Company, the location desired, contains the following provisions, viz.:

West End Street Railway Company.

" The right to lay down tracks located by this order is given upon the condition that the entire work of laying down the tracks, the precise location of the same, the form of rail to be used and the kind and quality of materials used in paving said tracks and on either side of the same shall be under the direction and to the satisfaction of the mayor, the city engineer and the superintendent of streets, and shall be approved by them.

" Also upon the further condition that said West End Street Railway Company shall accept this order of location and agree in writing to comply with its several conditions and file such acceptance with the city clerk within thirty days from the date of its passage, and also before proceeding to construct said tracks shall file for record with the city engineer, location plans and profiles of said tracks, which show the same in detail, together with the sidings, turnouts and connections."

If the location granted is to the Cambridge Electric Light Company for ducts or conduits, the order contains the following provisions, viz.:

Cambridge Electric Light Company.

" 1. The kind and quality of material used in the construction of said duct or conduit and exact location shall be under

the direction and to the satisfaction of the city engineer and the superintendent of streets and shall be approved by them.

"2. The board of aldermen, having first given the company or its agents opportunity to be heard, if in the judgment of said board the interests of the public so require, or if each and all of the above conditions, terms and requirements are not complied with, may order such duct or conduit or any of said ducts or conduits in this city and the wires therein to be removed, and the company shall thereupon remove the same in conformity with such order, and if the company neglects to execute such order and to remove said ducts or conduits after thirty days' notice of such order, the board of aldermen may cause the order to be executed and such ducts or conduits to be removed, and the expense thereof the company shall repay to the city.

"The location herein named is indicated upon a plan furnished by said company and filed with the city clerk."

If the location granted is to the New England Telephone and Telegraph Company, the order contains the following provisions, viz.:

New England Telephone and Telegraph Company.

"In every underground conduit constructed by said company one duct not less than three inches in diameter shall be reserved and maintained throughout its entire length, free of expense, for the use of the fire, police and other telegraph and telephone signal wires belonging to the city of Cambridge and used exclusively for municipal purposes. The city shall have equal facilities with the company for putting in, taking out and repairing its wires and cables of said conduit system.

"The right is also reserved to the city to connect from any other conduit system or from distributing poles, pipes or buildings, either municipal or private, to the manholes constructed by said New England Telephone and Telegraph Company of Massachusetts for the purpose of carrying the said telegraph and telephone signal wires owned by said city from one system of conduits or poles to any other system of conduits or to other poles or buildings; provided, however, that said company, if it shall so elect, may construct, build or provide the other manholes at its own expense for the use of the city in making connections with the ducts reserved for municipal signal wires as aforesaid.

"2. The authority herein granted is also subject to the right and privilege of the city, if it shall so elect at any time, and it

shall have the right, to purchase of said company, its successors or assigns, all or any part of said conduits at a price not exceeding the original cost thereof, to be fixed, in case the parties cannot agree, by the Chief Justice of the Superior Court at the time. In case the Chief Justice declines to serve, it shall be fixed by three referees, one of whom shall be appointed by the mayor, one by the said company and the third by the two before mentioned, and by accepting the authority herein given, said company, for itself, its successors and assigns, does thereby agree to sell upon the aforesaid terms to the city aforesaid.

"Within six months after the completion of the construction of the conduits built under the authority conferred by this order, or whenever, during such construction, the mayor shall so request, said company shall file with the city clerk a statement, in such form as the mayor shall require, showing the original cost of said conduits, said statement to be certified by the president of said company.

"3. In case of purchase as aforesaid, said company shall thereafter have the right to use said conduits by payment to the city of such rental, in case the parties cannot agree, as said Chief Justice of the Superior Court or referees may determine.

"4. Said company shall construct said conduit system in such locations in the said streets as may be designated by the city engineer and to the satisfaction of the mayor, the superintendent of streets and the city engineer. Within three months from the time of completion of the said conduit system, said company shall file with the city engineer and city electrician satisfactory plans showing in detail the location, size, depth, appurtenances and details of construction of the systems as built. The time, manner, place and duration of the opening of streets for the construction of said conduits, and the time within which the work shall be completed, shall be under the direction of the superintendent of streets of said city. Whenever said company shall dig open any street for the construction, maintenance, operation or repair of any part of said system, it shall refill and repair said street to the satisfaction of the superintendent of streets. In constructing said conduit system, and in making repairs upon the same, it shall employ Cambridge labor, with the exception only of skilled men required in the work.

"5. That said company, while using any part of the conduit system authorized by this order, shall, so long as it shall pay no compensation for the use of the streets occupied by said conduit system, in whole or in part allow and remit to the city a

discount of $33\frac{1}{3}$ per cent. from the regular rates established for exchange service for the use of its telephones by others in this city, for and on account of all telephones and other patents of and used by said company for the sole use of the city.

. . . .

"7. The said company before beginning work under this order shall accept this order in form of written acceptance dated ...., now on file with the city clerk, and shall give to the city of Cambridge a bond which shall be satisfactory to the mayor, conditioned to indemnify and save the city harmless from and against all claims, damages, cost and expenses and losses whatsoever to which the city may be subjected in consequence of the acts and neglect of such person or corporation, their agents, officers and servants, and any and all persons acting by, through or under such person and corporation and in any manner arising from and in any way growing out of the construction, maintenance and operation of said conduit system under this order."

Having obtained its location or franchise, the company now proceeds to obtain the necessary data for an exact location from old records, plans or excavation on the spot of existing structures, pipes, etc. From these data a more careful location is then determined and the work carried out. When finished, complete plans are filed with the city engineer showing the location, depth and size of structures built under the order.

As is common in most of the older cities of the country, the data concerning the locations of pipes, conduits, etc., belonging to the city and private corporations have been found in many cases to be very meager and unreliable in character, besides being scattered and difficult to obtain.

In order that these data might be collected and put in available condition for use when needed, in settling the constantly recurring questions arising regarding the proper locations for these structures, some years ago a tracing copy of the streets of the entire city was made upon a scale of 40 ft. to an inch, upon which the structures, pipes, conduits, etc., are shown by lines and figures in appropriate colors. Nothing else is shown upon these sheets but this.

All data as fast as obtained are put upon these plans, thus making the plans of increasing value and usefulness.

[NOTE. — Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by October 1, 1909, for publication in a subsequent number of the JOURNAL.]

METHOD OF OBTAINING AND PREPARING TRANSFERS OF PROPERTY FOR USE IN ASSESSORS' DEPARTMENT, LOWELL, MASS.

By Arthur Bartlett, Member Boston Society of Civil Engineers

[Read before the Society, February 10, 1909.]

In January, 1894, Mr. George A. Nelson, of the city engineer's office, read before this Society a paper describing in detail the methods employed in the survey for the city map of Lowell. This paper was published in the Society Journal for October, 1894, and can be referred to if a further description of plans or methods of survey is required.

The plans on file in the city engineer's office are on white mounted hot-pressed Whatman paper, 22 in. by 30 in., to a scale of 50 ft. to an inch. These sheets contain individual lots with their areas, dimensions and buildings, and, if the lot is a portion of a divided estate, the number of the lot as shown on the original subdivision of the estate. Copies of these sheets are made on Crane bond paper, showing lots, lot numbers and areas only, for the Assessors' Department. The names of the lot owners are then written in pencil as guides to the assessors in making their assessments on real estate.

During the first few years nothing was done to keep the sheets, already completed, up to date. In 1896 it was found that so many changes in real estate were constantly taking place that the plans and tracings were really unreliable for instant use. At this time the assessors were in the habit of sending two clerks to the Registry of Deeds to get all real estate transfers which they thought belonged to Lowell. These transfers, covering the years 1892 to 1896 inclusive, were turned over to the Engineer's Department as data for plan corrections. An examination of these records showed about 15 per cent. containing the necessary information, and it was thought best to talk things over. A conference was held between the principal assessors and City Engineer Bowers, and it was agreed that the Engineer's Department should obtain the real estate records in their own way, correct the plans and tracings and turn transfers and tracings over to the assessors correct to May 1 of the current year.

The following plan was then decided upon. A manifold book of 200 pages was designed with the original sheet perforated. This sheet was to be delivered to the assessors for their work, the copy to remain in book form on record in the Engineer's Department.

The work at the Registry of Deeds is done by one of the young men of the engineer's office, and as a book is filled and returned, the original sheets are removed, the necessary changes made on both maps and tracings and the sheets turned over to the assessors.

Before the end of the first year under the new régime, it was found that the assessors' records were not only incomplete, but very badly mixed, and it was decided to arrange a street index of the entire city. Cards were designed, a system arranged, and work on the index started in the spring of 1898. As this index was to be used for the levying of all municipal assessments, each lot had its own card so arranged as to contain all necessary data, as number of map sheet, all possible street numbers, areas, frontage of lot and date, book and page of record. These cards are kept up to date and are of very great assistance to nearly all departments. Work on this index, at the beginning, was very slow for many reasons. It was entirely new in every detail, it was impossible to take the data of the assessors and follow them regularly, most of it had to be dug out, and during the first two years only about five months' actual time was put in on this work. As the number of completed streets increased, the assessors realized the assistance it was to be to them, and plans were formulated for a card system for their entire work. After considerable time and study, in 1905 cards were designed and a system arranged for the Assessors' Department, so that now these transfers are received in the Engineer's Department, the plans and tracings corrected, the changes made in the street index and the transfers sent to the assessors, where the necessary changes are made on the street and ledger cards.

The question may be asked: What if one of these transfer records is lost? If that record arrives in the engineer's office it must show up somewhere.

In the first year of the adoption of this system nineteen errors in assessment were detected in the Assessors' Department, and this out of 10 076 accounts, each account averaging between six and seven items, and last year only three re-assessments were made necessary.

The number of transfers recorded varies greatly with the different years, 1 025 the smallest and 2 285 the largest, while

the total number taken for the past ten years is 15 800, or an average per year of 1 580.

The transfer, as originally taken by the young man at the Registry, contains the nature of the document, date of acknowledgment, date of record, book and page, grantor, grantee and location of property, and, if contained in the instrument, the area, frontage, lot number and reference to plan. About 10 per cent. of these records have to have the entire description copied, as it is the only way the lot can be located. About 50 per cent. of these transfers have either area or frontage or both missing. The time occupied by the young man at the Registry varies from sixty-three to seventy-eight days, but this includes any time that he may spend in copying plans that have been recorded during the year.

It is also necessary to obtain from the Probate Court the disposition of real estate by will, and the heirs of deceased persons holding real estate who died intestate. The time required to obtain these records is about ten days and the number of records varies from 63 to 285. These records are not copied in duplicate, but all information necessary for the Assessors' Department is copied and given directly to them.

With the exception of that portion of Lowell annexed from the town of Tewksbury in April, 1906, the street index is completed and up-to-date and we have within the next two months to complete this portion.

This street index is now used for real estate, street watering, sewer, sidewalk and moth assessments, and has contributed largely in reducing the number of illegal tax sales by the city treasurer.

[NOTE. — Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by October 1, 1909, for publication in a subsequent number of the JOURNAL.]

WILLIAM EIMBECK: A MEMORIAL.

By William H. Bryan, Member of the Engineers' Club of St. Louis.

[To be presented to the Club September 15, 1909.]

Among the charter members of the Engineers' Club of St. Louis who took part in its organization in the spring of 1869 was William Eimbeck, whose unexpected death in Washington, D. C., on March 27, 1909, was a shock to his many friends. He was buried April 1, 1909, at New Haven, Mo., where members of his family still reside.

William C. J. Eimbeck was the third son of the late Fried. Eimbeck, inspector of the Government Museum and Pheasantries at Brunswick, Germany. William was born in that city, January 29, 1840. He was largely self-educated, but also attended public and private schools, and later the Polytechnic and Agricultural College, under Prof. Dr. Roeleke, where he made phenomenal progress, particularly in mathematics. He came to the United States in 1857, landing in New Orleans and proceeding to St. Louis, where he accepted a position as draftsman with Palm & Roberson, builders of locomotives, then located at Third and Lombard streets. This company built many locomotives for the old North Missouri Railroad, now the Wabash. In 1860 he became assistant and deputy to Wm. J. Cozens, county surveyor of St. Louis County, and was later assistant to county engineers Gen. Charles E. Solomon and August Elbing. For these nine years his principal work was as civil engineer in municipal and county offices. He also did some work in connection with the Eads Bridge and the St. Louis water works, then actively under construction. He was tendered the offices of county and city engineer but declined in favor of men of family, he himself being and remaining all his life a bachelor. About 1868 he also became connected with Washington University, serving as its first professor of engineering and practical astronomy.

In 1870 he was sent by the United States Coast and Geodetic Survey to Sicily to observe the total eclipse of the sun, December 22, 1870. Missing the United States steamer at Naples, he was invited by Professors Lockyer and Darwin, Jr., of the British astronomical party, to accompany them on the steamship *Psyche*, en route to Catania, Sicily, to observe the same eclipse. Ten miles east of Catania the *Psyche* struck a rock and sank, and Mr.

Eimbeck reached Catania in a life-preserving boat, saving only his instruments and his Star Spangled Banner.

His most important work was in the United States Coast and Geodetic Survey, which service he entered permanently in 1871. This work is graphically depicted in the following passage from a letter from Mr. O. H. Tittmann, superintendent United States Coast and Geodetic Survey.

"His connection with the Service dates from 1869, when as a volunteer observer he observed the details of the solar eclipse of August 7 of that year. The Coast Survey had arranged for a chain of parties in the middle west to observe this phenomenon, who coöperated under the personal direction of Prof. J. E. Hilgard, then assistant in charge of the Coast Survey, and later superintendent of the same. Mr. Eimbeck was in one of the parties organized by Mr. Julius Pitzman, the county surveyor of St. Louis County, and was stationed at a point in the vicinity of Mitchell, Ill., and later assisted in the determination of the latitude and telegraphic longitude of St. Louis, and the connection with this astronomical base of the various eclipse stations in Missouri and Illinois. It is notable that this was the first exact determination of the longitude of St. Louis. The relations thus inaugurated led to his being selected as a member of the expedition which Prof. Benjamin Peirce, superintendent of the Coast Survey, took to southern Europe for observing the total eclipse of the sun which took place on December 22, 1870, Mr. Eimbeck being assigned to the party under the distinguished astronomer, Prof. C. H. F. Peters, with whom he made the necessary observations on Mt. Rossi, near Catania in Sicily. The ability and acquirements which were demonstrated in these two astronomical undertakings induced the superintendent to recommend to the Secretary of the Treasury an appointment in the Survey as subassistant for Mr. Eimbeck, and on June 5, 1871, this recommendation was approved, and the actual appointment was made on July 1. His first assignment was to one of the triangulation parties on the survey along the 39th parallel of latitude which was operating in Missouri, extending the work westward from the base in the Great American Bottom opposite St. Louis; and later he was engaged in astronomical duties in connection with determination of latitudes, longitudes and azimuths in Kansas, Texas and Louisiana.

"In 1872 he was ordered to the Pacific coast, and for the following five years was engaged in astronomical and primary triangulation work along the coast from Oregon to the entrance of the Gulf of California, one of his undertakings being a determination of the geographic coördinates and magnetic elements at thirteen stations between San Diego and Cape San Lucas for the control of the survey of the coast of Lower California, then in process of execution by the Navy Department. In 1872, in the superintendent's report, is an evidence of the thorough spirit in

which he entered upon securing a thorough command of all the details of the scientific operations upon which he was engaged, this being shown by his paper suggesting improvements in the Hipp chronograph, then used in connection with the telegraphic longitude operations.

"In 1877 he returned to the Eastern coast, where he was instructed to take up an extensive astronomical and magnetic campaign for the determination of latitudes, longitudes and the magnetic elements in Kentucky, Illinois, Tennessee, South Carolina and Georgia, and later, after making the necessary preparations, in 1878, was ordered to return to the Western coast and begin at Pah Rah, in Nevada, the extension of the primary work eastward from the coast triangulation, which was to follow approximately the 39th parallel of latitude to the capes of Delaware. This was the inception of what was to be main life work of Mr. Eimbeck and to which, for eighteen years, he gave all that was best in both mind and body. Stretching from the Sierra Nevadas to Pike's Peak in the east line of the Rocky Mountains, and including in its list of occupied stations mountain peaks reaching an elevation of 14 400 ft., in regions where supplies had to be carried for hundreds of miles through deserts and wastes, destitute of roads, and almost destitute even of water, the successful conduct of this work called for the endurance of the most rugged of pioneers and the undaunted courage of the explorer, while the operations represent the highest type of work demanded from the scientist and observer. In this triangulation one line, observed in both directions, is over 183 miles long and not exceeded in the work of any country; and another example which attests the giant character of the work is a spherical excess in one triangle of over two minutes.

"There are two instances where the change between adjoining stations necessitated a journey of 300 miles, one of these during the transfer of parties from Mount Ellen to Mount Tavaputs, made under the fierce suns of August and September, across a desert section which tested almost to their limits of endurance the men and animals, and it is remarkable to relate that in his most expansive moments Eimbeck never seemed to consider that any special merit could be claimed for successfully overcoming all these hardships and dangers. A reference to the annual report of the superintendent will emphasize this feature of our friend's character, as therein will be found only a simple statement of the work completed each year, because of the modesty which would not permit him to give an adequate account of the toils he faced and conquered. Coast and Geodetic Survey Special Publication No. 4 gives the details of the scientific feature of Eimbeck's great share in the measurement of the arc of the 39th parallel. His report on the Duplex Base Apparatus designed by him for the Coast and Geodetic Survey, and the report of his measurement of the Salt Lake Base with the same apparatus, are the two principal published reports prepared by Mr. Eimbeck."

Mr. Eimbeck's invention of the Duplex Base Apparatus, his design of an Invariable Reversible Pendulum, the improvement

of the Hipp chronograph, and his work in connection with the observation of eclipses, both in this country and abroad, were accomplishments which attracted the attention of scientists the world over. His survey from the Atlantic to the Pacific on the 39th parallel of latitude, which occupied nineteen years, was really his life work.

Ill-health and a desire to devote his time more closely to scientific research led to his resignation from the Survey in 1906.

He was a frequent contributor of scientific articles to magazines and journals, many of which were translated and published abroad. He was a founder of the Cosmos Club of Washington; a member of the Washington Academy of Science, the National Geographic Society, the Geological Society, and the Washington Philosophical Society, and for thirty years a Fellow of the American Association for the Advancement of Science.

He was a man of pleasing personality, but of such modest demeanor that few knew of his accomplishments and attainments. An interesting appreciation of Mr. Eimbeck's work and personality is the memorial address delivered May 22, 1909, before the Philosophical Society of Washington, by Mr. Edwin Smith, of the Coast and Geodetic Survey, published in *Science* of July 9, 1909.

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HEAT: ITS USE AND DISTRIBUTION.

BY LYMAN C. REED, MEMBER LOUISIANA ENGINEERING SOCIETY.

[Read before the Society, May 10, 1909.]

SINCE the subject presented to-night has been of absorbing interest to physicists for many years, I approach it, and desire to present it to you, from the standpoint of a student and not an instructor. Many volumes have been written on what must here be briefly sketched, and the endeavor will be to transform our appreciation of heat phenomena into an active instead of passive acceptance.

To the average layman the problems connected with our use of heat appear detached and isolated. He fails to grasp the correlation of the various manifestations of heat phenomena. Ordinarily the word " heat " is used to denote an appreciable rise in temperature above that which our bodily senses label as normal; but the word has a much broader meaning, and the farther the investigation proceeds the more we find that forces set in motion by heat transference are integral with life itself.

The philosophy of heat is the study of its transference from one body to another, and without transference heat is useless as a work agent. All mechanical effort of whatever nature can be expressed in its equivalent heat value, and vice versa. Therefore, in considering heat phenomena, we must study its manifestations if we desire to arrive at a true appreciation of its relation to our present civilization. In dealing with the various forms of heat and its transference, no attempt will be made to more

than outline their general relationship to each other and to the source of all heat.

Heat is transmitted by radiation, conduction and convection. Radiant heat is transmitted by the ether which permeates all matter and stellar space. Heat by conduction is transmitted by molecular activity along the same substance or from substance to substance in contact. The transference or shifting of heat by convection is only possible in liquids or gases where masses of heated material are shifted bodily into contact with other masses, the final heat transference taking place either by radiation or conduction.

The earth receives heat from many sources, but its chief supply comes in the form of radiant heat from the sun. The active principle which makes the sun the supplier of heat for our planetary system is purely a matter of conjecture, but the most recent discoveries in atomic activity would seem to point to the transformation of the sub-atomic kinetic energy into heat as the maintainer of the sun's heat. That radiant heat is purely a force carried by the ether, and not an atomic or molecular transmission, is evidenced by the extreme cold on high mountains. The heating of the atmosphere and earth is accomplished by the force in the impinging ether waves being transformed into molecular activity which becomes sensible as heat. The ether may therefore be considered as an elastic medium through which the molecular activity of the sun is conveyed to the earth, the intervening space being in a state of absolute cold. By means of the hydrogen thermometer the absolute zero, or state of matter or gas where all heat is absent, has been determined as 273 degrees cent. (below freezing point). At this temperature all molecular motion of matter ceases, and it is presumed that this is the temperature existing in stellar space.

The atmosphere which envelopes the earth furnishes a medium that enables us to exist, and its temperature varies in different zones and seasons, this condition being brought about by the changing relations in position of the earth and sun. Minor local disturbances are set up by air and ocean currents caused by varying heat conditions, but the atmosphere as a whole acts as an equalizing agent, and all objects enveloped therein tend to become of the same temperature. A piece of ice placed in a bowl and exposed to the air becomes of the same temperature in time, as likewise does the red hot iron removed from the fire. The ice can only remain ice when the air is warmer than it is by an expenditure of energy, and the iron can remain hot by the

same means. The surrounding air is temporarily cooled by the melting ice and likewise heated by the iron, but the cooling and heating are equalized and blended until the melted ice, iron and air reach the same temperature. The quickness of this blending is dependent upon the value of the heat insulation separating the objects. Where the objects differ greatly in heat potential the instant blending of their heat values results in many cases in violent disturbances similar to the disturbance caused by the short circuiting of electric currents of high potential. It is much more difficult to insulate for heat than for electricity as nearly all solids and liquids are fairly good conductors of heat, while many substances are practically perfect insulators for electricity.

If a pound of iron at 400 degrees fahr. be immersed in a pound of water at 100 degrees fahr. the resulting temperature of the water and iron will be about 124 degrees, neglecting the loss from radiation. This resultant temperature will be rapidly reduced to that of the surrounding atmosphere. Now if the pound of iron instead be placed on a table a foot away from the vessel containing the pound of water the iron and water will be reduced to atmospheric temperature without the iron having appreciably raised the temperature of the water.

From the above is deduced the law that bodies of differing heat potentials are equalized in temperature along the lines of least resistance.

The mere fact that the earth and atmosphere are such large quantities in comparison with other objects makes their temperature the controlling factor in all heat equalization.

As heat is recognized as molecular vibration, it is apparent that all objects in a state of heat equilibrium vibrate in synchronism, and when this vibration is accelerated or diminished by a change of state or condition the temperature is said to increase or decrease as the case may be. A change in temperature can be produced by the direct application of heat or by various other equivalent means, but in order to keep the object from synchronizing with its environment the application must be maintained. The work thus performed or energy equivalent may be expressed in concrete form and has been defined as the mechanical equivalent of heat. The amount of work represented by raising the temperature of one pound of water from 60 to 61 degrees fahr. is equivalent to the force necessary to lift 778 lb. through 1 ft. It is evident, therefore, that the momentary energy equivalent to any object raised above or depressed below the

temperature of its environment is expressed as 778 ft. lb. multiplied by the number of B.t.u. contained in the object. This energy may not be in shape to use commercially, and frequently merely represents the transference of heat from one body to another. All heat values are in a constant state of mutation, and it is fair to assume that the heat received by the earth from the sun during one complete orbit just balances that which the earth radiates during the same period, otherwise we should either roast or freeze in a short time. Thus all matter, including the earth and atmosphere, when raised above the temperature of its surroundings, tends to return to the absolute zero but is arrested in its progress by encountering a temperature maintained by the sun's influence.

The quantity of heat in any earthly object is so infinitesimal in comparison with the sea of heat in which it is immersed that it is only a question of time until a like temperature is reached. In the same manner any matter which has been carried below the temperature of its environment either by artificial or natural means cannot descend lower without the expenditure of energy, but is restored to the temperature of its surroundings by transference of heat to it from surrounding bodies.

A simple explanation of these phenomena of heat transference is furnished by the theory that all matter radiates heat, the object of low heat potential having its molecular vibration accelerated by the surrounding objects of higher heat potential, the whole earth being kept in a state of heat activity by the ether waves received from the sun. It is worthy of notice that all heat transference takes place from the warmer to the colder body.

Does not the question here arise whether the mean temperature of the earth is a rough measure of the power of the ether waves impinging thereon? The fact that any substance exposed to the hottest rays of the sun does not rise above 200 degrees fahr. shows that the sun's rays unaided cannot excite a greater molecular activity than that of which this temperature is the index. Greater temperature can be obtained by focusing the rays through a reflector or lens; the momentum of the impinging ether waves is not changed nor their intensity, but they are simply added together.

A simple analogy would be furnished by dropping a flat disk of large diameter and a rod of the same weight from a given height. The impact would be the same, but the penetration of the rod would be far greater than that of the disk.

The difficulty in focusing a quantity of the ether waves to

raise a large mass to higher heat potential has been the stumbling block in our utilization of the sun's rays for power purposes. Another analogy is presented in our large rivers of low head; the quantity is there, but the potential or head renders their use of little value.

Before passing to a consideration of the use of heat, a few of its most salient properties will be noted.

Radiant heat, light and electricity are transmitted by ether waves of different lengths and frequencies traveling at the rate of 186 000 miles per second. Radiant heat waves impinging against a mass are transformed into molecular activity in proportion to the mass's thermal conductivity.

Light waves impinging against a mass are either transmitted, reflected or absorbed, according to the nature of the substance.

When electricity is transmitted over a conductor it travels with the speed of light but sets up in the conductor a molecular activity proportional to its conductivity which manifests itself as heat. Such metals as silver, copper, mercury, iron, etc., exhibit approximately the same thermal and electrical conductivity, showing that the molecular resistance to heat and electrical transference is in the same ratio.

It takes an appreciable time to heat a conductor either by electrical or thermal means, but a conductor of uniform cross section and given length is equally heated in all parts at the same time by the passage of electric current but very slowly and in diminishing degree from the heated to the colder portion by conductive heat. A molecular mass is, therefore, necessary to conduct electric current of low periodicity such as we use commercially, but offers a screen to radiant heat varying in effectiveness with the nature of the substance. Can we not consider the heat manifested in an electrical conductor as a sort of molecular friction caused by the ether waves in passage, particularly in view of the fact that the heat generated is directly proportional to the cross section of the conductor?

The recent developments in radio-activity and the marvelous heat-giving qualities of radium have changed the theory of atomic activity into one endowing the atoms with active particles called electrons which contain an electric charge. These electrons are about 1–1 000 the size of the hydrogen atom and are supposed to revolve in groups forming atoms. The emanations from radium seem to consist of these highly charged electrons, and 1 gm. of radium in disintegrating gives out as much heat as the combustion of a ton of coal.

Heat in the abstract is, therefore, more possibly activity of the electrons than molecules themselves, and the intensity of this activity defines the amount of heat. A blow, a radiant heat wave, a convection current of heated air and the thing we call substance responds at once to the greater activity, in turn passing it along to some other substance, all by means of an elastic medium which permeates all things, yet is unseen, unfelt, untasted, — the ether.

A great similarity exists between the laws of heat and the laws of gravity. Bodies at rest remain at rest unless energy is exerted to move or set them in motion, and the same rule applies to a change in temperature. The energy needed to disturb a body can be expressed in both instances in heat equivalent.

The law of gravity may be expressed in B.t.u. value of the stored potential and kinetic energy imparted to a body in motion. Thus 1 lb. of iron raised 1 ft. from the ground in one minute represents when released a B.t.u. value of .077 units. Bodies at any temperature above absolute zero require the expenditure of energy to keep them stable and this may be imparted by the surrounding objects; their net loss equals the object's net gain. Any change in equilibrium either through the law of gravity or heat transference causes an object to give out a heat or mechanical value.

The absolute zero which all matter reaches when heat is absent may be used as a base from which to calculate heat potential, as the center of the earth is used as a base in gravity calculations. The temperature of any body on the absolute scale is momentarily its index of heat stress or potential. To illustrate: A pound of water at 60 degrees fahr. would equal 519 degrees on the absolute scale, and its work equivalent above absolute zero is 519 multiplied by 778 ft. lb. A pound of iron at the same temperature would have the same work value divided by the ratio of its specific heat to that of water, which is about 9. In like manner, any mass's absolute work equivalent may be determined. Between two objects of the same temperature, no heat passes; therefore, no work is done. It is only by raising the heat of one above the other than work may be done. All commercial work, therefore, resolves itself into the transference of heat from a high potential to a low potential body.

In passing to the discussion of the use of heat, we have seen that all energy in its final analysis is the work done in the equalization of temperature between different bodies, and it is necessary in order to use it commercially to have this equalization take place in such manner that it can be readily utilized.

The evaporation of water by the sun's rays, and its subsequent precipitation in the form of rain or snow, which, in turn, is stored in the earth and gradually conveyed by rivers to the ocean, constitutes an energy cycle which continues ceaselessly. The portion of this cycle which deposits rain or snow renders possible the growth of vegetation which through long processes of the ages has been transformed into coal, natural gas, oil, etc. All of these substances possess given heat values which, through certain well-known processes, man converts into available heat of higher potential.

The vegetation nourished by rainfall helps the rain to filter into the soil and be given out gradually in springs and rivers. The unevaporated portion of this water finally reaches the sea, where it is again evaporated and put through the same cycle. The process of evaporation, being a continuous one, has piled up enormous quantities of stored heat equivalent in the form of coal, oil, gas and forests, all of which may be considered as by-products of the great evaporation cycle in which our water powers are by far the largest exponents. The amount of the sun's energy thus stored is estimated as only about 1-1 000 of that delivered to the earth.

The fact that the earth is not at all points of an even surface causes the water that is deposited to seek the point nearest the center of the earth, acting in this way as an agent of the law of gravity. Water in traveling from a higher elevation to a lower can be made to give up a heat equivalent or work value proportional to its mass and fall. The total aggregate of such power reaches many million horse-power and is continuously available. The non-utilization of this heat equivalent is a great economic waste which we have scarcely begun to remedy.

Coal, oil and gas have been heavily drawn upon for fuel purposes, and the supply is rapidly diminishing without a chance of their being renewed. The forests have also been greatly depleted for fuel and other purposes, and unless the destruction ceases our water powers will be greatly impaired and their availability for fuel or heat correspondingly injured. The artificial storage of the direct heat of the sun has not been satisfactorily accomplished, and until this problem is solved we must depend on water power and other means before mentioned to furnish our commercial heat and energy.

The animal kingdom outside of man has no knowledge of the use of fire or other forms of heat, and this knowledge is one of the greatest factors in marking the barrier between certain animal

species and the lower orders of man. In other words, our expertness in the use of fire or other forms of heat is in a great degree the measure of our advancement in the animal kingdom. In our daily lives, artificial heat in some form or its mechanical equivalent is at the foundation of nearly all our conveniences and activities. The ancient Greeks made the snatching of fire from the gods the distinguishing event in the development of man, realizing that without heat in its various forms we should not have risen above the level of the beasts. The words, "heat, energy and power," are used synonymously in this discussion as they are interchangeable terms.

The heat demands of our present civilization are so enormous that we can already look forward to the time when the stores of coal, oil, gas, etc., will be so depleted that other methods of deriving artificial heat or energy must be found. No doubt the pressure of necessity will solve the problems as they are presented.

The value as a heat producer of any of the present agents at our command is measured by its B.t.u. value. In deriving heat or energy from original storage elements the mechanical equivalent of heat is the end usually sought, but the cycle is never complete until this mechanical equivalent has been again resolved into its primary state — heat. The use of any particular storage unit from which to obtain its equivalent in direct heat or mechanical equivalent is generally determined by its cost and availability. A further modification is introduced by the sub-agent employed in distributing the heat units or energy made available. It is the purpose of this treatise to define broadly, the best methods of economically using and distributing the various heat storage elements placed at our command.

The principal sub-agents employed in direct and indirect heat applications are air, water, steam, gas and electricity. These sub-agents are the conveyors of high potential heat to places where the heat equalization or work equivalent is used.

Direct heat applications may be considered to embrace the heating of buildings, furnaces, cooking utensils, etc., while indirect heating includes these and the various mechanical and chemical equivalents used in commercial life.

The development and utilization of water power as a means of performing useful work dates back many hundreds of years, but the development was insignificant until the discovery of a suitable distributing agent. Broadly speaking, the heat units represented by the energy of a water power are constant, and the

final dissipation into various forms of mechanical equivalents are misleading only in so far as we fail to realize the final values of the transformation.

Early users of water powers were confined to running small mills principally for grinding grain and sawing lumber. Later, mills and factories located on the banks of streams where water power was available obtained their power through water wheels and, through the agency of shafting and belting, were made to perform mechanical work on a large scale. It was not until the advent of electricity as a distributing agent that water power could be used economically at a distance from its site, either as a direct heating agent or in some form of mechanical equivalent.

In transforming the energy of a water power into electric power a certain percentage of the original power is not transformed in the manner desired but is given off in heat in various ways. The friction of the water in the penstock and wheel, the friction of the bearings supporting the wheel, and the various losses in the generator itself, all manifest themselves in the form of heat which is given off to the surrounding objects and dissipated.

The conversion of the electricity generated into mechanical or heating and lighting effort shows another loss varying with the degree of efficiency of the translating units. The total amount of heat equivalent generated is finally diffused and equalized at atmospheric or surrounding temperature or stored in some latent form for further transformation. The process of analyzing the complex quantities involved in each transformation is beyond the intent of this discussion, but it is desirable to keep in view the conception of heat equalization as broadly outlined. The economy of heat distribution by means of various sub-agents ranks among the absorbing economies of our race and is kaleidoscopic in viewpoint.

Nature's most generous gift to man is water power, and its preservation and utilization are among our chief concerns. In order to preserve the water power, the forest must be preserved, which in turn contributes to our coal supply. Thus we see that the great original energy storage agents are so interlinked as to be inseparable; their intelligent use must appeal to us as a duty.

In utilizing the water power as a distributer of heat it is found that electricity offers the most efficient sub-agent. As much as 70 to 75 per cent. of the energy of the water power is thus made available for a distribution whose efficient radius is being constantly enlarged. The development of long-distance

transmission has been rapid, and systems are now in use where the power is used four to five hundred miles from the site of the water power.

In order to make this transmission of power a success a market must be found or one created for the sale of applied heat in its various forms. Among the largest users of applied heat is the city, as the number of heat units used per capita is much larger than in rural districts. The demand for light, transportation, heating and factory operation represents a greater unit activity in cities than in rural districts and, in fact, the capital investment is so great to reach a widely scattered rural district that it seldom pays to distribute heat units from a central source. This condition is modified where a central supply system traverses a rural territory to reach a market further on. Latent storage agents such as coal, wood and oil are used to furnish individual heating needs both in city and country where the cost of obtaining heat units from a central supply system is prohibitive. This statement is misleading on analysis because in any instances the additional load of this class of heat users would make a central distributing system commercially profitable by reducing the fixed cost per unit.

While the energies of water powers are almost universally distributed by means of electricity, some of them, as has already been cited, are transformed directly into mechanical effort. The final dissipation of this mechanical energy manifests itself in the form of heat or its latent equivalent. Even where extended distributing systems are not contemplated, it is frequently found that power distribution is more cheaply accomplished by electrical than mechanical means. This applies especially to large factories and industrial plants scattered over large areas. In plants where the absorption of energy is purely mechanical, its entire equivalent is dissipated in heat, but in many instances a certain proportion of the energy is stored in the form of latent energy. In the manufacture of calcium carbide and other chemicals a portion of the energy used in their production is stored and held in suspense until released at man's option. The generation of acetylene gas from calcium carbide and water makes a gas that is suitable as a direct heating agent and when ignited completes the cycle started at the water power. The storage battery may be taken as another example of latent heat or energy accumulator where the final dissipation of the original heat value of the current stored is held in suspense until the battery is discharged and the current reconverted into direct heat or its mechanical equivalent.

In transforming a water power into electricity only a portion of the available power is liberated in heat at the time of transformation, but in the transformation of wood, coal, gas or oil into electricity, the present process is to liberate the entire available heat units by combustion and then absorb as many of them as possible in some sub-agent for distribution. This process takes place in our present boilers where the water is used as a link in the cycle of transformation. The average loss in this first transition between the heat released by combustion and that absorbed by the water in the boiler is about 40 per cent. of the original heat value of the fuel. This 40 per cent. is spoken of as lost because it is not available for useful work. The remaining available 60 per cent. may be distributed for primary heating purposes either as hot water or steam. The convection principle is employed in the use of hot water or steam as heat distributors, but the local application in heating large buildings or groups of buildings is accomplished by radiation and convection. Cooking and washing are also among uses these sub-agents fill, but are seldom available from a central distributing system. Owing to their limited availability hot water and steam are not widely used as heat distributors for other than primary uses, such as direct heating and driving steam engines.

It has been shown previously that the efficiency of a water power was as high as 75 per cent., and it has just been shown that the efficiency of an ordinary boiler is about 60 per cent., demonstrating that for direct heating purposes the water power is the most efficient, but owing to cost of development may not be the best to use commercially.

Steam may be styled a low potential and electricity a high potential heat distributor, the low potential being best suited for short distances and the high potential for long distances. Low potential distribution by steam fulfills so few needs that we are compelled to transform it into high potential heat equivalent, — electricity. The loss between the heat value of the coal and its final equivalent in electricity averages about 90 per cent. This wasting of our natural resources is only condoned by our ignorance; we have not been able to do any better. A comparison with water-power efficiency shows how much better we have mastered mechanical properties of primal heat transference.

Other forms of sub-agents for heat distribution are in extended use and gas may be considered the chief form from a standpoint of direct heating value. A pound of coal of 14 000 B.t.u. heat value transformed into gas would give an average of

5 cu. ft. of gas of a total thermal value of 3 000 B.t.u., — not much better than 20 per cent. efficiency. The by-product coke, tar and other ingredients of coal all have a heat value which makes the apparent result less wasteful. Gas admits of much more extended distribution than steam, and in many instances, particularly with natural gas, is transported hundred of miles economically. In view of the variable heat values of the residue left from a pound of coal converted into gas it is very hard to consider gas alone as a sub-agent of heat distribution by assigning it a definite efficiency of transformation. This phase of the problem had best be taken up under a later head wherein the commercial efficiencies of the various sub-agents will be determined.

Natural gas and crude oil are among nature's primal heat storage agents and form a group secondary in importance only to the three principal agents considered. Natural gas is almost universally applied directly as a heating agent and is transformed through gas engines into a mechanical equivalent for the performance of useful work. These gas engines may in turn drive electric generators. The efficiency of transformation of natural gas into electricity is much less than water power into electricity. The thermodynamic efficiency of a gas engine may be as great as 25 per cent. and the electric generator 97 per cent., making a combined efficiency of 24 per cent., as against 70 per cent. obtained from a water power. Natural gas is directly comparable to a water power, and where conversion to electricity must be performed for distribution it should never be burned under a boiler where the final result in the form of electricity would average not better than 10 per cent. of the original thermal value of the gas. The same argument applies to crude oil, and it should be considered a criminal waste of natural resources to burn oil or gas under a boiler for further transference into mechanical or electrical power.

Having briefly outlined the relation of the various primal heat storage elements and their use, it is in order to tabulate them so as to fix them in their permanent relation.

Water-power conversion to electrical or mechanical equivalent 70 per cent. efficiency.

Coal, wood, gas or oil under boiler to hot water or steam equivalent 60 per cent. efficiency.

Coal, wood, gas or oil under boiler for mechanical or electrical equivalent 10 per cent. efficiency.

Coal or oil into producer gas 20 per cent. efficiency plus coke, tar, etc., as by-products.

Natural gas, manufactured gas, crude oil, converted in gas or oil engine 25 per cent. efficiency of the fuel value.

The same converted into electricity, 24 per cent. efficiency.

From the above it is seen that of all the primal heat storage agents, water power at present furnishes the one we can use most efficiently. This use, however, may entail a greater cost of development and utilization than some cheaper transformation from other elements. This would probably be the case in the presence of a large pocket of natural gas or oil which for a brief period would furnish heat at a minimum cost. But all such sources of heat are exhaustible; our supply of coal, oil and gas is so well defined that it is merely a matter of calculation as to the number of years they will last at the ever-increasing yearly rate of consumption. The great continuous sources of energy that are constantly renewing themselves are the water powers and the forests. As long as the sun shines on the earth the cycle of evaporation, condensation and precipitation will take place and produce our rivers from which we derive our water powers. The forests act as the equalizers or governors of the run-off, so that we have a somewhat average flow throughout the year. The excess forestation or growth may be utilized for lumber, fuel, and the thousand and one purposes to which it is put. If these forests are destroyed the greatest agent we have for the use of primal heat is taken away, and it would only remain to exhaust the already depleted coal, gas and oil fields to destroy our present industries and civilization. This feature is dwelt upon because it becomes imperative for us to solve the problem of the most economical use of our primal storage agents in order to conserve them as long as possible. This brings us to the general deduction that all forms of direct or indirect heat application should be carried out by the agents or sub-agents offering the most economical use of the original primal agent. We must capitalize the primal heat agency, giving the B.t.u. a primal value from which all derived values must be taken. Thus a water power may be expressed in equivalent B.t.u. value, a pound of coal, a gallon of oil, or a cubic foot of natural gas or a cord of wood. That a basic cost per B.t.u. is proper may be proved by reducing the interest charge on the cost of development of a primal agent to its equivalent B.t.u. value. In other words, all energy, whether represented by human labor, stone dams or turbine engines, has an equivalent B.t.u. value. Thus we say that the cost of delivering a horse-power of electrical energy per year from a given water power is $10. This $10 represents fixed charges,

depreciation, operating expense and a reasonable profit on the investment without any value being placed on the water itself outside of the cost of the original water rights. Reducing a horse-power year to its equivalent B.t.u. value, we find that the cost is 0.000045 cents per B.t.u., or 4½ mills per 10 kilo-B.t.u.'s, of derived energy. This represents the basic B.t.u. cost of this particular water power in the form of electrical energy. The additional costs of transmission and transformation are not included in the above.

Coal at the mine may be compared to a water power. The cost of coal delivery at the mine mouth should include the cost of mining, interest on the investment, sinking fund and a reasonable profit. Assuming this value at a dollar per ton, and an equivalent B.t.u. value of 14 000 units per pound of coal, a value of 3.6 mills per 100 kilo-B.t.u.'s is found to be the basic value in direct heat units. As has been pointed out, this heat value transformed through steam into electrical energy would give a cost of 3.6 mills per 10 kilo-B.t.u.'s without any addition for fixed charges on plant equipment, which formed the greater portion of the cost in the water-power estimate. Assuming the cost of $75 per horse-power for plant equipment, and calculating interest and depreciation at 10 per cent., operating costs at $3.50 per year, we should have a charge of 4.5 mills per 10 kilo-B.t.u.'s, making the total cost per 10 kilo-B.t.u.'s, 8.1 mills. This proves that under the most favorable conditions coal cannot be burned under a boiler, transformed into electricity and made to compete with water power at $10 per horse-power per year, but is equivalent to a water power at $17.50 per year. The same coal used in a producer gas generator and the gas utilized in a combustion engine will give far greater economy in the use of fuel, but owing to the greater cost of the plant the final economy is not very much better.

With coal at $3.00 per ton the comparison is greatly in favor of the producer gas plant, as the fixed charges and operating remain the same, the values being 15.3 mills for steam and 11.4 mills for producer gas per 10 kilo-B.t.u.'s. As a rule, all gas engine plants are more expensive than the equivalent steam plant, varying from one and a half to two and a half times the cost of the steam plant. If the same interest and depreciation are charged on both equipments and the operating cost worked out, it is an easy matter to determine from the fuel cost which type of plant is best for a local condition.

If direct low potential heating is required it can be

generated, including the boiler cost, at less than one mill per 10 kilo-B.t.u.'s, which is practically 22 per cent. of the cost of high potential heat distributed from a $10 per year horse-power water power. Many low-head water powers that will cost huge amounts of money to develop will remain in their present state as long as the cost of other forms of stored energy can be applied more cheaply. The cost of coal, oil, natural gas is certain to increase as the quantities become more limited, especially if the problem of storing and using the direct heat of the sun remains unsolved for commercial application. In time this will force the development of every possible water power, and the intrinsic value of the water power will be further modified by the character of the market to which it must look for support.

The comparison between coal and water power in the foregoing was based on the cost of coal at the mine, but if coal be figured at $3 or $4 per ton, as it must be for some sections of our country, the comparison becomes still more unfavorable. Equalizing factors may exist in the market being a great distance from the water power, in which event the interest and depreciation on a transmission line would possibly offset the greater cost of coal. Determinations such as these must be made for each local condition. The easiest way to solve the problem for any locality is to ascertain the intrinsic value of a kilo-B.t.u. of the nearest water power and compare this with a like value for coal, natural gas or oil at the nearest point of delivery, adding to each value the cost of delivery per kilo-B.t.u. at its market. Assuming a cost of ¼ cent per ton mile for transporting coal and a haul of 400 miles, we find that it would cost $8 650 to deliver 1 ton per hour each day of the year. This is equivalent to an average of 1 000 e.h.p. per hour if generated in a steam plant. The transmission of a 1 000 h.p. 400 miles, assuming the cost of the line to be $4 000 per mile, and interest and depreciation at 10 per cent., and line loss at 10 per cent., would be $161 000 per year, showing that it is much cheaper to transmit the raw material than its equivalent in electrical energy. The above will apply to gas and crude oil in even greater degree. If, instead of transmitting 1 000 h.p. per hour electrically, we transmitted 20 000 h.p., the cost for interest and depreciation on the line would remain practically the same, but the cost per 1 000 h.p. would be $8 050 as against $161 000; 10 000 h.p. would cost $16 100 per 1 000 h.p. This shows that a balancing ratio exists between the cost of transmitting raw material and generated power, and where large quantities of power are used many cities or industrial plants could

save money by removing their plants to the coal mine if water power was not available. The continuity of service is sometimes of greater value than a lower cost of production, and until long high voltage transmission systems are rendered more reliable, the steam plant will exist in localities where its economic existence should end.

In the foregoing determinations values are predicated on plants delivering large quantities of power at an average rate. A plant's load factor is very essential in determining cost, and the higher the load factor the cheaper an electrical unit can be produced. Any central distributing heat system must, therefore, try to maintain as high an average load as possible in order to keep the cost per unit of fixed charges down. It becomes incumbent on such a system to supply a community or city with a selected heat supply system so that every demand is studied and the most economical service devised to fill the need. After the basic cost per B.t.u. for any community has been determined by an exhaustive study of local conditions, the cost of furnishing each B.t.u. need of the community is the problem to be solved.

[NOTE. — Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by November 1, 1909, for publication in a subsequent number of the JOURNAL.]

A SPECIFICATION FOR FILING AND INDEXING RAILROAD PLANS.

By Herman K. Higgins, Member Boston Society of Civil Engineers.

[Read before the Society, January 27, 1909.]

When, some eighteen years since, the writer entered the engineering service of a certain railroad, not so large then as later, their drawings were roughly classified as land, track, bridge, building and miscellaneous plans. There was no index; plans were supposed to be put away in their proper drawers. Finding a plan was very simple: we looked in its proper drawer; if not there, in any other drawer that seemed likely to contain it. Out of regard for his reputation for veracity, the writer will not state how many men he has seen hunting for hours for some much-desired plan that had strayed from its place.

A few years later the writer was transferred from construction to office work and it became part of his duty to keep run of the plans and records pertaining to bridges. By that time the track, building and land plans had been sub-classified according to geographical location, one drawer for each division, etc. Bridge plans had also been subdivided, on the basis of Blueprints *v.* Tracings *v.* Brown paper, etc., single structures appearing in all the classes.

One of the writer's earliest innovations was the sorting out of plans pertaining to each structure without regard to quality of paper. These were then fastened together, marked with the number of the bridge and kept flat in order of such numbers, one drawer for one or more geographical divisions of the road. The bridge numbers were geographically consecutive; each branch began with number 1, and the numbers progressed as far as necessary.

The same system of numbers was recently, and, so far as the writer knows, is still in use on that line, its most undesirable feature being the necessity for interpolating whenever a new structure is established. As long as the original numerical system for interpolation is adhered to, there is little trouble, but the addition of letters combined with pre-existing fractions results in some such combination as $10\frac{3}{4}$ E a.

The writer believes it rarely necessary to change a system of bridge numbers, and, if such system goes back well into the past, such change usually involves the loss of many valuable data,

as the old numbers are forgotten in a few years and the many references in old requisitions, letters, notes, etc., become thereby unavailable for all following seekers after data.

This self-indexing system worked very well as long as drawer room was available. In course of time the road, with several others, was absorbed into a larger system, the offices were consolidated and it became necessary to store the plans in a fireproof vault. They had to be rolled, and the self-indexing feature had to be abandoned and an index provided.

One of the consolidating companies already had a book index, or, rather, list of plans of all kinds classified according to name of nearest passenger station. The bridge plans, the writer's work was still largely with bridges, were (on the road with book index) often found rolled up with plans of other work, cross sections, profiles, maps, masonry, earthwork, station plans, etc., all in the same roll. The system of numbering rolls was very simple. It began at 1 and had reached some 6 000 odd at the time the writer made its acquaintance. The book in which the index was kept was divided alphabetically. Each station had assigned to it a certain amount of space as its importance seemed to warrant, the stations being as far as possible alphabetically arranged. The arrangement of titles under the station names was chronological, as it was not practicable to continue and maintain the alphabetical arrangement.

In filing the plans of the other component roads it was attempted to continue and expand the above principle. A number of difficulties arose which are indirectly referred to later. Another of the component roads had a really excellent index, well classified and with all necessary data entered therein. This was largely due to its having been burned out a few years before, nearly all its records (of Engineering Department) having been burned. It had thereby a clear field and few old records to reindex; there were, therefore, only a few plans. The serious fault with the index was that it was divided by operating divisions of the road; these often change, and in this case had changed several times. Each division had a separate book, and to find a plan the seeker must either know which division it had pertained to *at the date of filing* or must look through several books.

At the time above mentioned of expanding the "station name" system of filing, the card system was introduced, largely through the writer's recommendation, the book mentioned being all copied on the cards. This formed the nucleus, a very re-

spectable one, for the present rather satisfactory index on the road in question.

There remained something yet to be desired for an index of bridge plans, and a later paragraph will show its development.

Long before the consolidation of the roads the writer had foreseen the need for a comprehensive index and had taken up somewhat thoroughly the study of indexes and self-indexing systems. There was at that time very little in print on the subject, and he was obliged to begin nearly at first principles. By the time the consolidation of the offices and consequent rearrangement demanded action in caring for bridge data, a system was well outlined and the details presented little trouble. The writer has since formulated the system in the following specification, if it may be so called. It is intentionally simple, and, so far as applied, worked perfectly for some four or five years, growing all the time. It could not be fully applied to the case in point as there was much conservatism to be overcome and little intelligent clerical assistance to be had.

The "specification" is made as full and complete as possible, the fundamental principles and the "reasons why" are given in considerable detail to the end that it may be clear and perhaps useful to readers who have indexes to make.

The writer uses the term "specification" as he intends this paper as in some sense a protest against the filing *system*, so-called, as applied to records of engineers' offices. Filing systems work well in some places; so do the characters used by stenographers; so do cipher codes. In all three there is no possible check on the one or two men who hold the key to the system. The writer wishes to express his emphatic disapproval of all cipher code filing for engineering records, and that is what much of the code filing really is. His reasons for this disapproval will be found in a later paragraph.

1. General considerations.
   Index *v.* self-indexed files.
   Notes, memoranda, etc.
   Letters and old books and papers.
   Plans.
2. Definition and scope
3. Form.
   Facility, simplicity, certainty.
   Cards *v.* book.
   Size and quality of cards.
   Arrangement: Alphabetical or otherwise.
   Number of indexes.
   Speed *v.* certainty.
   Cross indexing.
   Elimination of dead matter.
4. Plan files.
   Form and size.
   Numbering units.
   Numbers on plans.
5. Book and document files.
6. Computations, diagrams, etc.
7. Conclusion.

1. A business just starting usually requires no elaborate filing system as the person in charge of the office can remember where things are. As the business grows, data and records accumulate and more men are employed. It then becomes necessary to systematize and to keep all data where not only the chief, but also the assistants, can find them at short notice. At this point we meet an alternative: we can file in a self-indexing system, or we can file in any convenient form, and index the file.

In case the data are of suitable nature and form, the self-indexed file is usually the better and cheaper. In collecting data it is well to put them into convenient form for such files.

The writer has for years kept notes of surveys, inspections, formulas, diagrams, etc., and memoranda of all kinds, on ordinary Library Bureau cards. The larger size, about 4 by 6 in., is preferable for field notes of surveys; for most other purposes the standard size, a trifle less than 3 by 5 in., is preferable. For field use they are tied together into book form with stiff leather covers. They are filed by subjects in an ordinary cabinet of standard form and size. After cross referencing they are absolutely and permanently accessible.

For extended surveys covering many pages, and for work in which notes cannot be put on sketches but must be kept with them, an ordinary book is sometimes preferable. Moreover, such survey notes once plotted rarely need to be referred to again and the book is convenient enough; but for detached surveys, notes of inspections and, in general, all divisible work, cards (or loose leaves) have great advantages. They may be sent into the office for draftsmen's use without interruption to the outside work, and returned if necessary, or filed. On city or town survey work it is much easier and safer to carry a dozen or so cards bearing notes of former surveys of tracts adjacent to the one under survey than to carry as many old notebooks. Those of us who have done much city work, so-called, do not need to be told that old notes are likely to be of very great value in such work. If it is attempted to copy them into the current notebook, one is likely to omit the one thing most important, which omission is discovered later in the field.

Records of bench marks, reference points and the like are very conveniently kept on cards and tied into the back of the made-up notebook. The cards should preferably be kept in the office when not in actual use to attain greater safety against loss or accident.

The loose-leaf notebook which operates on the same principle,

that of divisibility, has many friends and the writer prefers it to the old-fashioned book, but he has found the cards easier to care for and more accessible when filed. This principle of divisibility is the same as that requiring letters to treat one subject only on each sheet; this principle is almost universally applied to correspondence, and its recognition in technical files will prove as profitable as it has already proved in letter files. Many other applications of this principle will suggest themselves; the main point is to plan beforehand for the filing and to get the original data in convenient and divisible form. The writer has several professional acquaintances who use this card system for field notes, memoranda, etc., and who would not abandon it on any account. Usually letters, bills, receipts, time returns, requisitions and most clerical papers can be kept in a self-indexed file, which may well be cross referenced in the general index. Some offices own as most valued possessions old plans, notebooks, etc. These are usually not susceptible of self-indexing; old plans almost never are. They must, therefore, go into an indexed file.

2. The dictionaries tell us that the word "index" signifies "to point out." An index is usually conceived to be a contrivance to enable one to find something the location of which he does not know. It does this, but if properly made will do much more. It should at least answer with speed and certainty the three questions, "Is there on file anything pertaining to the subject in hand?" "What is there?" "Where is it?" It should in addition give such particulars as scale, if a plan or sketch, date, source of information, and such description as will fully identify the data in the mind of the seeker. A thoroughly worked out index should also have references to pertinent data known to exist in other offices, whether or not such office is allied to the indexing office; data on public record, data contained in professional or trade books or journals, and, in general, to any source of data which are likely to be useful.

3. The form of an index must necessarily vary according to the needs of each particular office and should have the following general qualities: It should be easy to handle, to reduce to a minimum the cost of using it; it should be simple, to enable its use by persons of little education, i. e., the lower grades of help employed in technical or other offices; it should be certain, to enable a person of ordinary intelligence to speedily run down the desired data, and be sure none has been overlooked.

One is tempted to assume that, in this age of cards, no one

would dream of putting a current index into a book. A finished index, e. g., an index to a treatise, is, of course, not to be confounded with a current index, which forms the subject under discussion.

There are just two apparent advantages in a book, namely, the index is always together, and no part can be lost without losing the whole. The first advantage is apparent only, as indivisibility is, in an office of any size, a disadvantage, as only one person at a time can use the index. The second is fallacious in that the loss of any part of an index is in any event only a matter of office discipline; a full drawer of cards cannot easily be lost, and only the indexing clerks should ever be allowed to take cards from their places in the drawers.

The positive advantages of cards really include all the advantages of a good as opposed to a poor index and all that follows may also be taken as an argument for cards (if, indeed, argument is needed). Perhaps the most important of such advantages is that it allows the fullest use of the alphabetical form; this eliminates the loss of time each time the index is used, caused by having to read page after page of irrelevant matter. As such reading is almost necessarily hurried over, and to some extent slighted, the element of certainty is to that extent lost.

Quality, manufacture and size of cards. — The quality and size of cards is of some importance. The paper used should be tough, hard and close grained, heavy enough to handle easily and not too heavy to bend safely.

Perfection of manufacture is very important as it governs the speed and, to some extent, the certainty of the index. The cards should be all of exactly the same size, edges should be clean and square. These two qualifications especially should be insisted upon, even at considerably increased cost. The cost of the stationery is in any event a very small fraction of the total cost of the index, and it is truest economy to buy the very best the market affords. Good cards cost money to make; poor ones are almost worse than none. The same is true of cabinets in which to store the cards: the best are none too good. Size is a matter of personal preference. The writer has used nearly all sizes to some extent, and for indexes proper prefers the 75 by 125 mm. size, a trifle under 3 by 5 in. They are large enough and not too large for comfortable handling.

Arrangement, alphabetical or otherwise. — There is in the human mind a strong tendency to specialize and complicate.

Accordingly we find in much filing that some arrangement other than alphabetical is adopted. The non-alphabetical arrangement presupposes knowledge on the part of the user of the system upon which the index was constructed. This means that each newly employed assistant must learn the system before he can effectively use the index. In case the system is complicated, as a non-alphabetical system almost necessarily is, he must devote a considerable amount of time to learning it, which time has to be paid for by some one and is a dead loss. New men are likely to form a considerable fraction of the force, and the loss of time learning systems of records amounts to considerable. The alphabetical arrangement is intelligible to any one who would have occasion to seek for data in such index, and enables the utilization of low-grade help, — office boys, messengers, etc.

In the indexing of records of an engineering office the question "how many" is sure to arise. The tendency to complicate mentioned above here asserts itself, and there are in some offices as many indexes as there are varieties of records. The writer believes in as few indexes as possible, keeping permanently valuable technical records separated from clerical records and records of ephemeral value. If the filing is done comprehensively, even this division is superfluous, as with cards it is always possible to eliminate obsolete and to insert additional matter.

Speed v. *certainty.* — Speed is important and is attained partly by the free use of guide cards, but more by comprehensive planning in the beginning. Certainty is by far the most important element in the use of an index, and can only be attained by careful, painstaking work by competent persons, in making and keeping it. Who does not know that feeling that the reason for his non-success in seeking is solely that he has looked for the wrong word and that the desired data must surely be at hand. It is still more important in making additions, or in eliminating dead matter, to make sure that nothing has been done to obscure old data, or separate data that belong together. These several forms of certainty involve, after careful work, the intelligent use of cross references.

Cross indexing, or, preferably, cross referencing, is essentially a reindexing under an additional caption; e. g., a bridge plan should be indexed under the name of the street or river, under the number, if numbered, under the name of the township, if named, and under the name of the nearest station if on a railroad, and often under many other captions. Many filing clerks

put the file number on all the cards. This is wrong; the number should appear only under the most important and permanent caption; all the others should refer to that caption instead of to the file number direct. There are several reasons for this: it is sometimes necessary to move records to another place; it is sometimes necessary (convenience may be a form of necessity) to divide or to reindex the data referenced on one card; it is often desirable to eliminate obsolete records. If only one card bears the file number it is very easy to change it or to insert a substitute, or to enter the permanent record of elimination; in such cases the cross references do not need to be disturbed. In case the file number appears also on the cross reference cards, a change of any card must be entered on all, and if by inadvertence one be missed, it will surely make trouble in the future, and may cast a doubt on the correctness of the whole index. These errors are in practice certain to occur; they can be minimized only by a complicated system of recording all cross references. Why do so when the error may certainly be avoided by the simple expedient of numbering a single card? Many cross references mean increased certainty, provided numbers appear on one card only; otherwise many references mean decreased certainty. The writer has often been asked such questions as "Where is the Widow Dean bridge, the Narrow passage ferry bridge, India bridge?" etc. Such questions always indicated the need of another cross reference card. Some one knew the answer; when it had been looked up, and the card inserted, any one could easily find the desired data. It will be objected that it takes time to look for a second card. True, and the extra time is unimportant compared with the certainty that all data on file will surely be found on that card. Suppose a plan turns up (they often do) marked Town River Bridge. The index clerk looks for the card "Town River Bridge," finds it, and enters the plan also on the card marked Bridge No. 217, also on the card with the town name; he forgets that this bridge is also known as Red Bridge, also as Jones Ferry Bridge. Six months later the chief calls for plans of Jones Ferry Bridge; his clerk looks, or the file clerk does, and produces certain plans, not including the one above mentioned. It may be worth thousands of dollars to be able to produce that particular plan in court; unless some one hears of it who happens to have known that the plan exists and was filed and looks it up, the matter will go by default; the production of other plans will in such case obscure the existence of the one really valuable plan. Of course,

instead of a plan it may be a modification of a lease or agreement, or data of agreement as to classification of a cut, or terms of a contract for extras, etc. The main object of an index is to enable one to find data he does not know of, and this object is defeated under the circumstances noted. The probability of such errors is not at all remote. The writer knows of many bridges which are known to different people by as many as four arbitrary names besides the geographical names and number; the same is also true of other structures, farm surveys, etc. He has also known of suits at law lost because of inability to produce plans that afterward were found improperly filed. He has known file clerks to fail on just such a proposition as this.

In case of cards referring to data, plans, etc., in other offices, public record offices, etc., it is usually best not to attempt to give file numbers, but rather to refer to the office only and describe the plan or data, depending on the local index for more particular location. The reason is that files are apt to be changed or may be divided and rearranged. References that are not permanently correct are inadvisable in an index, as they may become misleading.

The writer's experience indicates that the best form for bridge index is as follows: Primary index. Name of street or river. This card is made as nearly complete as possible, e. g.

MAIN STREET BRIDGE 114, MILLSDALE, PA.

Iron — BBW — shop — Bl — 10 shts — $\frac{3}{4}$ in. = 1 ft. — '04	14 – 17 – 2
Abuts and Piers — Trac — 4 shts — $\frac{1}{4}$ in. = 1 ft. — '04	12 – 27 – 14
Floor — RR — Trac — 1 sht — $\frac{1}{4}$ in. = 1 ft. — '05	14 – 25 – 10
Railing — RR — Trac — 1 sht — 1 in. = 1 ft. — '04	14 – 10 – 17
St. Ry. tracks — St Ry — Bl — 4 shts — $\frac{1}{2}$ in. = 1 ft. — '05	14 – 11 – 4
Notes of survey	See survey file
Stresses for class E street car	See computation file

In case there are many plans of one structure the writer has found it advisable to index under the sub-captions, site, masonry, superstructure, tracks, floor, etc., grouping the plans or notes under each sub-caption on one or more cards.

This bridge might have many or few cross references, which should be somewhat as follows: Bridge No. 114, Millsdale, see Main Street; Millsdale Bridge No. 114, see Main Street; Howes Crossing Bridge, see Main Street Bridge 114, Millsdale; Town Road Bridge, see Main Street Bridge 114, Millsdale; Dr. Burgess Bridge, see Main Street Bridge 114, Millsdale, and so forth. Whenever an additional name turns up it should be entered on a new card and referred to the primary card as above.

Cards bearing survey and inspection notes, computations, memoranda, etc., should be cross referenced as above in the general index. This insures that references to all data on any particular subject will be together and none will be overlooked. Reports, requisitions, some letters, etc., if of permanent value, can profitably be cross referenced the same way in the main index. Cards bearing survey notes, etc. (original data), also computations, should, when possible, be kept in a fireproof vault. The general index should be in the most accessible place, in a good light and convenient to get at. The ideal arrangement is a stand on casters or wheels, capable of being easily put into and kept in the vault when the office force is absent.

The elimination of dead matter from a file or index presents some very serious problems. It is so very easy to err in judgment, and, in the interest of convenience, discard data or notes of no apparent present value, which by some unforeseen circumstance become valuable later. On the other hand is the danger of loading down the file with much non-pertinent and obsolete matter. Non-pertinent matter should not get into the file. It sometimes does and with obsolete matter may need to be removed. The writer believes that, as a rule, the index should include all obsolete data on file. The card should be marked "obsolete" or "obs." opposite each such item, and when the card is finally removed it should be kept in a special "obsolete" case or drawer for at least one or more decades.

4. Plan files.

Plans and drawings of all kinds should be filed in drawers or pigeon-holes of suitable size. Any one who has looked for a profile or narrow drawing rolled to, say, 12 in. long, in a 48-in. drawer or space, will not need to be told why. The writer has seen highly-paid men, after the clerks had failed, attack a pigeon-hole containing thirty or forty rolls, and deliberately withdraw each roll separately, expecting to find the desired plan in the back end of the space behind the other plans, and consequently not visible nor accessible without such process.

This fault is usually due to some official or chief clerk, who seldom uses the file, wishing to keep all plans of some class or division together in a certain location. It will readily be seen that if the index is consulted to learn the space and file number it is entirely immaterial in which case or drawer the plan is kept. It should, therefore, be placed where it will be kept most accessible and best protected. A 12-in. roll behind a 45-in. in a 50-in. pigeon-hole is in serious danger, and is itself a serious danger to other plans, as such a file will abundantly testify.

The form of plan files is subject to very wide divergence of opinion; drawers and pigeon-holes seem to be preferred, also racks in some cases. The writer prefers for drawings of reasonable size, say up to 30 by 60 in., a filing case containing drawers or sliding shelves not more than 3 in. deep inside, 2 in. even better, of size to suit the drawings, in which the plans, tracings, etc., are kept filed flat. The drawers should have sheet metal (non-corrosive) corner covers at the back, and springs at the front corners, to hold all four corners of the plans down in place.

For rolled plans of considerable length, similar drawers can be used, but the writer prefers a case of pigeon-holes or shelves with partitions. Each unit space, drawer or pigeon-hole can profitably be made to hold forty or not to exceed fifty sheets or rolls. In some climates it is necessary to provide damp-proof tubes in which to keep the rolls; these may well be of size to hold thirty or more drawings and fit into the filing case. Spaces in all filing cases should not be too deep, and a reasonable assortment of sizes should be provided, as every office needs to preserve plans or prints from other offices, which do not conform to its standards for size. This difficulty is sometimes met by rolling each plan around a stick or tube of standard length, which bears on its end the file number of the plan it belongs to. This has the advantage of keeping the plan in excellent condition, but introduces a chance for error in rolling, inadvertently, a plan on the wrong stick. It is also uneconomical in space and weight, as well as in first cost. Of course expense should be incurred only when the resulting advantage is worth it.

The limit of fifty plans or rolls to each unit is based on observations with the seconds hand of a watch and is, of course, a compromise. The cheaper the labor employed looking up plans, the larger the unit can profitably be made. It is usually of advantage to plan the units of size for fifty plans, and leave them partly filled. Offices having many standard size plans or plans and maps in sets find the shallow drawers, or sliding shelves, a profitable investment, as they save many times their cost in wear and tear of plans.

Numbering file units and plans. — It is usually possible to devise a system of numbers at once so simple that it is obvious and so comprehensive that it will provide for indefinite expansion. The number of digits used should be as small as is consistent with comprehensiveness, and they should be combined to give as many permutations as may be. All present and probable future sub-offices and branches should be included.

A large engineering office or department would naturally include a vault for fireproof storage, a main drafting-room, several specialists' rooms, a clerical office, and, perhaps, a number of local survey or construction offices. Each of these would have a file of plans and records, and nearly every one an index of its own plans and records at least. It hardly needs to be stated that there should also be a general index, accessible to all, and preferably located near the vault and main drafting-room. All these should be covered and differentiated in the first figure or digit of the plan number, e. g., a number beginning 01, 11, 21, might refer to a plan in the vault, in the main drafting-room, in the bridge specialist's room respectively. It would be a large department that would require more than ten such offices or rooms.

The second figure or digit should refer to the filing case or bank of such cases. For any one at all familiar with the file, it would be unnecessary to remember these numbers, as they would represent so large a section of the file that they would automatically represent the idea of the location, leaving the mind free to remember the remaining more characteristic numbers. At the same time, a new employee could soon find any case desired.

In subdividing filing cases or bank of cases, it is usually possible to number by groups of ten, making it easy to locate a given number. Especially when designing such cases this should be kept in mind. It is as easy to divide a given space into ten as into twelve parts, and the convenience so attained is a very great gain, well worth the trouble involved.

The third, fourth and fifth digits, which should preferably be separated from the first two by a dash or hyphen, should represent the ultimate file unit, pigeon-hole or drawer, and give latitude enough with properly arranged cases, for a very large file. Ten thousand file units in a single room are really too many for safety, and before this number is reached the file should be expanded into another room. The final two digits number the individual sheet in the file.

It may occur to some one that it is not desirable to file plans in a drafting-room or a specialists' room, and that all plans should be filed in a vault or fireproof room. There is undoubtedly opportunity for good judgment in deciding which plans to leave out of the vault and which to put in; nevertheless it is now, and without doubt will continue to be, the custom of all or nearly all engineering offices to keep some or many of their plans in such

places, and there is a large class of plans that can be properly so kept. These plans should be indexed in the general index, and should form an integral part of the one comprehensive file. In case plans are moved from one room to another it is not difficult to correct the index if the numbers are properly kept on one card only, as specified above. It need not be said that some one man, preferably a clerk, should have it a definite part of his duties to attend promptly to all filing and changes of file numbers. He should, of course, be governed by carefully drawn rules, should be always and in detail under the direction of the chief draftsman or office engineer, whose time is not thereby wasted, as is often assumed, but is a good, often a very good, investment. One of the ablest engineers known to the writer once told him that "he had only one man good enough to file and index plans, to wit, his highest paid subordinate." In a busy office the chief will rarely be able to find time to actually do the indexing himself; he must then leave the actual work to a file clerk, but should supervise it closely.

The file clerk should preferably put away all plans after they have been used, to insure their getting into their proper places, and should see to it that all tears, rents, folds, etc., are attended to.

The files, and especially the indexes, should be open to the use of all employees of the office, whose duties require use of the plans or data filed. The practice of having files and indexes open to the examination of file clerks only is vicious in the extreme; though fortunately not common, it is still met with often enough to require its mention and condemnation. A file clerk is rarely omniscient; he is usually less intelligent than the average draftsman, who will nearly always be able to run down a desired plan far more quickly and certainly than the file clerk. Complicated or difficult searches for old and poorly indexed plans or data are, of course, possible only where files and indexes are open to the use of the draftsman or specialist who knows what to look for, and the various names by which the data may have been known and filed.

The above does not cover sets of plans like the Geological Survey, for example. The writer prefers for such plans an index sheet showing the boundaries of the various sheets, the plans proper being practically self-indexing by latitude and longitude, or, if necessary, by a letter and number. The reference in the general index would be to the set, and the index number should appear on each sheet of the set, to insure its reaching its proper place in the file.

5. Books are apt to be unsatisfactory from a filing standpoint. They usually contain many subjects more or less closely related to the title; to index them comprehensively requires much time, and anything less falls short of what an index should be. A careful reading of the book is usually a prime necessity, and to be satisfactory this and the indexing must be done by some one conversant with the subjects treated. The bulk of the indexing proper is cross referencing. Periodicals are not so bad, as the amount of pertinent matter is less. Trade circulars and catalogues are often very complex, and only rarely contain permanently valuable matter. Those that do will repay careful indexing and cross referencing; some of the data they contain may be invaluable.

Documents are analogous to plans. Large files of deeds, leases, etc., can sometimes be profitably indexed on a map of suitably small scale. In such case the general index should have a reference in general terms, e. g., " Deeds," see Deed File, Map No. 26 — 32 — ; Leases, see " Deed," etc. (the file occupying the unit 26 — 32 —), the individual deed, lease or whatever it is, being filed by a number on the index map. Isolated documents should be treated the same as plans.

6. Computations have in the past usually been kept in books, and more or less, usually less, comprehensively indexed. The writer believes there is a better way, and has seen it in use in a very few offices. Computations should be made on paper of standard size to fit standard filing cases — typewriter size is about right. The computations proper, with the data, diagrams, sketches, reference to notes, etc., all on the standard paper, ruled or plain as needed, are held together by a suitable fastener and kept in a self-indexed, cross-referenced file. Many years' experience has taught the writer that, whenever possible, copies of all original data, memoranda, etc., should be filed with the computations, also copies of diagrams used, or at least a reference to some other computation where the same diagrams have been filed. The writer has had occasion many times to refer to old computations of bridge stresses, where no definite load diagram was referred to. It was a long, tedious job to work it back from the figures given. He has of late years made it a practice to keep load diagrams, tables, etc., on tracings of about 5 by 7 in., a print being gummed at one end and fastened into the computation book where needed; of course this in an office where the rules required books to be used.

7. Since the above was first written, some five years ago.

there have been a number of systems for indexing proposed in the technical press, many of which the writer has seen and studied. Of these many are excellent provided the index is of limited scope, and is to be used only by highly trained men. The writer has seen none, and has seen mention of none, which meet the fundamental requirements laid down above, viz., simplicity sufficient to allow its efficient use by relatively unintelligent help, certainty as outlined above, and wide adaptability.

[NOTE. — Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by November 1, 1909, for publication in a subsequent number of the JOURNAL.]

THE FILING SYSTEM OF RECORDS IN THE ENGINEERING DEPARTMENT OF SALT LAKE CITY.

By O. H. Skidmore, Member Utah Society of Engineers.

[Read before the Society, March 19, 1909.]

To properly understand this system, it will be necessary to give a slight outline of the organization of the department, which consists of the following:

The City Engineer as the chief, and a Principal Assistant Engineer; then four division assistants, having charge of four separate divisions, namely:

1. The street division, taking care of paving, sidewalk construction and grades for same.

2. The sewer division: the construction, operation and maintenance of sewers.

3. The water-works division; the construction of water-mains and superintendence of the city's canals and waterways.

4. The electrical division locates poles and supervises the work of the various public-service corporations operating under franchises in the city in the laying of their underground conduits and stringing of wires, and also looks after such electrical equipment as is controlled by this department.

Besides these divisions, there is a drafting room, in charge of a Chief Draftsman; a computing room, in charge of a Chief Computer; and the public office, in charge of the Chief Clerk, who deals with the public and has the general supervision of the clerical force. The filing department is carried on in a commodious vault by a head filing clerk and assistant. The department operates a cement testing laboratory, in which samples of all cement used in municipal contracts are tested, and no small amount of custom work is handled; and also a blue print room is maintained, in which prints of all the drawings of the department are made.

Early in the year 1906 Mr Kelsey found that, with the beginning of the era of improvement, and the large amount of records already in the vault of the department, a new, up-to-date system of indexing and filing was needed. The office became an office of record, and a precise system of keeping these records was an urgent need. After careful study and few experiments, the present separate "leaf" system was matured.

Beginning in the field, with the completion of the day's work such notes as are taken are the next morning checked in the computing room, given their account numbers and sent to the vault for filing. With the mention of account number the system has its beginning. The department has issued for the employees a small paper volume containing the different account numbers and the account they represent.

Under the head of Contingent Fund are the numbers 1 to 20; these include expense, resurvey, private surveys, subdivisions and additions, and the other departments which this office assists with engineering.

Water Supply, numbers from 21 to 30, includes the accounts of the water resources of the city with the irrigation maintenance and construction.

Water Works, numbers from 31 to 35, includes the supply mains, water-works department construction and maintenance and the water-main extensions.

Streets and Sidewalks number 36 to 45, and include all the extensions pertaining to the improvements of the streets.

Sewers and Drains number 46 to 50, and include the drainage and sewer departments, both construction and maintenance, and the sewer extensions.

From this it can be seen that each principal account has its own account number. Now with the principal account number each one has its sub-accounts, and in order to clearly show such, let us take the water-works account.

Covering water-works proper, the account number is 31 to 31–Z, taking in the alphabet; supply mains, 32; new water supply mains, 32–B; city creek pipe line, 32–J, and so on to 32–Z. Water-works department (maintenance) is 33 and sub-accounts contain grades and lines for hydrants and pipes, city maps, electrical survey of water-pipe system, etc., to 33–Z; water-works department (construction) is 34, with sub-accounts under plans, estimates, etc.

Water-main extensions have the number 35, with the particular extension number as the sub-head. Water-main Extension 181 would be accounted for as 35–181. These accounts are carried through the bookkeeping and all parts of the office work.

When the City Council makes the appropriation for the department it is divided up among the various account numbers and their subdivisions, which amounts are placed to the credit of each account number, and expense connected with such work in material and time is charged out as work is done.

To simplify matters the principally used accounts have

special colors designated to them, and are used in the field notes and folders for letter and estimate filing. Water-main extension notes and all folders pertaining to water works are light blue. Paving extensions and their folders are pink. Sidewalk extensions and their folders are coffee color. Sewer extensions and sewer department work, light green. Notes and folders pertaining to the electrical department are light gray. Private surveys are corn color. Street profiles are tuscan.

When the notes for filing reach the vault, the filing clerk notes the account number placed on the notes by the checker and places them in the cabinet drawers designated by such numbers. The drawers have subdivisions in them corresponding to the subdivisions of the accounts before mentioned, and are easily identified.

The forms of field notes are divided into as many as are necessary to complete any class of work, being single sheets folded 16mo size. The first page has a blank for account number, extension or permit number, total of particular surveys, remarks and names of field party and date. The two inside pages are regularly ruled for either level or transit notes. The last page is left blank. Where special work is necessary, as in the measurement and location of the hydrants and valves, there is a specially ruled form with proper headings to fit such work. A copy of the inspector's notes is also made up on these special leaves, and is ruled accordingly. With the completion of an extension or some special work, these field and inspector's notes are bound in book form and preserved for record.

Following this same system of record, all the correspondence of the department pertaining to each account is similarly filed in folders, cardboard front and back, and bound to it with fasteners. Carbon copies of all outgoing correspondence are also filed, and a complete record of the accounts can be had by referring to these folders, which bear the number of their account.

All the computations are made in the computing department, and here a great number of ruled forms are used, special care being taken to have all forms of either of the two sizes for filing, standard letter size or the 16mo size of the field forms. In this department all the records and computation of the water supply are made, and these require quite a number of forms for stream measurement, and those necessary for the Utah Lake pumping plant, the city engineer being the representative of Salt Lake City in the Associated Canal Companies. In making up the partial and final estimates the computers use small forms (note size) for their computations and estimates,

and these, after being checked, go to the stenographer. All the estimates are rechecked by the assistant engineers and then await approval. Located in the computing department there is also a Challenge-Gordan press and complete outfit. This is used for lettering tracings and the indexing systems.

The most complex problem that confronted the office was to find a simple yet efficient system to file the tracings and drawings. There are at the present time 4 125 tracings and 1 058 drawings.

Five sections of steel cases were purchased, each having ten drawers and one drop door compartment. The drawers take any drawings up to 42 in. by 42 in. and hold with ease an inch and a half of tracings laid flat. The drawings and blue prints are filed in wooden cases similarly constructed, and rolls, such as large maps and cross sections that cannot be filed flat, are placed in the large lower spaces fitted in both wooden and steel cases with drop door fronts. The fronts of the drawers are provided with card slides for the account number, and the drawings and tracings are filed according to the account number system previously mentioned. These tracings and drawings are indexed according to the same system, and, turning to the account number, one can readily find at a glance the drawing or tracing desired. To further facilitate finding drawings or tracings they are also cross indexed by title and account number.

In connection with the department, and most valuable for record purposes, is a complete photographic equipment. As the work on any public improvement is susceptible to many law suits, just and unjust, photographs are taken during the various stages of the work. These progress photographs are undoubtedly the best witnesses the city can have. There are at present on file, indexed similarly to the other records, 1 873 negatives in two sizes — 6 in. by 8 in. and 8 in. by 10 in. These photographs have paid for themselves many times over by the winning of suits by the city through these mute witnesses.

Aside from the tracings and drawings are the Plat books which have been made both of the blocks of the city and the entire sewer systems. The block Plat books are made up of heavy drawing paper mounted on canvas, and bound with hinge binding so that the pages will always lie flat. All pages have numbers corresponding to the block number, and the plat of the book is first outlined on the page, showing all the monuments on the four streets bounding the block, together with the ties for same. Then, as private surveys or resurveys of the

city are made, all such are entered upon the outline drawings of the blocks. Separate books are made for each plat division of the city.

The sewer plat books, of which there are now twenty-five, are made in the same manner as the block books, and have along the center of the page the plan of both sides of one block of a street, showing the monuments at the two intersecting streets at each end of the block and their pluses from the base line, at the section of the city in which they are. The sewer line is drawn in, showing the location by pluses of all Y's and manholes. At the top of the page is a profile of the sewer, showing the grade and rate, manholes and ground levels of the one side of the street, and at the bottom of the page is the profile of the opposite side of the street. These books are arranged in districts and numbered according to their respective numbers, carrying on the front page an index to the blocks which each page covers. In addition there is a map of the city, showing all sewers, drawn in in colors and a number corresponding to the number of the book in which they are to be found.

All permits which are issued by the department, such as sewer connections, pole permits, house numbers, cement tests and the like, are typewritten on printed forms in duplicate, the original remaining in the office and the duplicate going to the applicant, who signs a printed receipt in duplicate which is on the form of permit of both original and duplicate. After all records, such as these permits, note sheets, letters, calculations, estimates, and in fact all but drawings and tracings, become a year old, they are bound in permanent bindings for record. These bindings are lettered with the account numbers and sub-letters to which they belong, and are placed in glass-front cases. These bindings also carry the color of the class of work to which they belong, thus making the records in all the stages quickly recognizable and showing by their distinguishing color, number and letter to what part of their particular division they refer.

The system has been developed and elaborated during the past three years under the personal supervision of Mr. Louis C. Kelsey, the present city engineer, to whom the credit is due for one of the best and most complete systems of records, if not the best, in the country.

[NOTE. — Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by November 1, 1909, for publication in a subsequent number of the JOURNAL.]

INDEXING USED IN THE ENGINEERING DEPARTMENT OF THE TOWN OF BROOKLINE.

By Henry A. Varney, Member Boston Society of Civil Engineers.

The system of indexing now in use in the Engineering Department of the town of Brookline was devised in the year 1902, after considerable study of the methods used in several of the larger municipal engineering offices in New England.

Everything is indexed under the name of the nearest street and also cross indexed under every other street referred to in any way. Plans, notes and documents are indexed separately and at present there is a fourth index for "Land Plans," which, however, can be combined with the main plan index at any time.

Standard sized flat plans are always used when feasible and are filed in shallow drawers and numbered consecutively in addition to the designations explained below. Not more than fifty plans are ever filed in one drawer. When large plans cannot be avoided, they are rolled and filed in pigeon-holes or plan tubes.

"Land Plans" are copies of plans recorded in the Norfolk Registry of Deeds relating to property in Brookline. They are made on tracing cloth and are always filed flat.

Drawers are lettered and numbered, the letter referring to the the bank or section of drawers, and the number to the position of the drawer in the section. It might possibly be better to number the drawers consecutively and so do away with the section letter, as plans are sometimes put away in the wrong section by mistake and so lost for an indefinite period, and again, it makes one more designation to remember when looking for a plan.

White cards of medium weight are used in indexing, about 3 in. by 5 in. in size, with tabs to designate the different classes of work. No colored cards are used except for guides and subguides, the former being buff and the latter blue. The tabs are of such size as to allow space for twelve classifications. For the plan and note index ten are used at present, as follows: Map, street, sewer, drain, park, building, bridge, land plan, water and miscellaneous. By the use of these tabs it is possible to locate the required card very easily, thus saving time and preventing the index from becoming unwieldy with growth.

On plan index cards the street name is written across the top, then below this at the left is a space for the filing numbers, and at the right, room for a description of the plan and still lower down are ruled places for the date, scale, engineer and material. Only one reference can be put on these cards.

For the Land Plan index the street name is placed in the upper left-hand corner, and the side of the street on which the property is located, at the right. The next line below is for the names of the streets between which the property shown is located, and the lower part of the card is divided into vertical columns for the owner's name, engineer, scale, date and place of filing.

In connection with the plan index a "Drawer" book and "Accession" book are used.

The Drawer book is for the purpose of showing what spaces are available in drawer or pigeon-holes for plans about to be filed. Two pages are reserved for a drawer and are headed with the section and drawer number. Down the left side of each page are the numbers 1 to 50, with an additional column for the accession number, and to the right of that column a space for a brief title.

The Accession book gives all the information relating to a plan and enables it to be located if the index card is misplaced or lost. In this book is recorded the full title, scale, date, size and material of each plan under an individual or "accession" number; also the initials of the assistant by whom the survey was made and plotted, the purpose for which it was made, and where and under what streets it was filed. Every plan made by the department is given an accession number whether it is to remain in the office or is for record.

In indexing notes they are arranged under subjects in addition to the tab classification. Calculations, estimates, levels, profiles and surveys are some of the "subjects," about twenty being used. This classification is written in the upper left-hand corner of the card, the opposite side being reserved for the street name. Below are vertical columns for the date, book and page and a brief description. The vertical ruling makes it possible to put several references relating to the same subject and street on a card, thereby reducing the number of cards in the index.

The loose leaf system has been adopted for street line and grade work and for sewer construction, and this has cut down the growth of the note index, as the loose leaves are filed in the same manner as cards behind the proper street name and do not have

to be indexed. If the loose leaf idea was applied to all classes of notes, calculations, estimates, etc., it would eliminate the necessity of a note index except, of course, for the old books.

The document index is for all correspondence, reports, estimates, bids, descriptions, specifications, etc. Everything is indexed under the name of the street to which it refers, as in the plan and note index, and, in addition, the correspondence is indexed under the person's name from whom the letter is received or to whom it is written. These latter cards are filed in a separate drawer. The tab card system is used here also, the tabs referring to the above-mentioned subjects. The cards are further classified by the use of sub-guides cut in "sevenths" and labeled "street," "sewer," "drain," "park," "water," "bridge" and "miscellaneous." If the document to be filed was a description of a street location it would be indexed on a "description" tab card and placed in the index behind the sub-guide marked "street." A space is reserved at the top of the card for the street name, a vertical column ruled down the left-hand end for the date and a similar one down the opposite end for the folder and document number. This leaves a generous space between for a description of the document.

The documents are filed by the vertical system, in legal size folders numbered consecutively. No more than fifty sheets are allowed in a folder and each paper is stamped with the number of the folder as well as an individual number. This enables one to locate any document exactly and if any are missing there is no chance for speculation as to whether or not there ever was such a document filed there.

The number of plans in the department has more than doubled since the index was started, but any required plan is as quickly and easily found as at first; in fact, the system, throughout, has proven very satisfactory and capable of indefinite expansion.

[NOTE. — Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by November 1, 1909, for publication in a subsequent number of the JOURNAL.]

FILING AND INDEXING DATA IN THE OFFICE OF THE CHIEF ENGINEER OF ELEVATED AND SUBWAY CONSTRUCTION, BOSTON ELEVATED RAILWAY COMPANY.

By Herbert C. Hartwell, Member Boston Society of Civil Engineers.

[Read before the Society, January 27, 1909.]

In preparing this paper, the writer has attempted only a brief outline of the system of numbering, filing and indexing data in the office of the Chief Engineer of Elevated and Subway Construction of the Boston Elevated Railway Company.

In this office all plans on file are divided into four classes, namely:

Office Record plans, which include all plans drawn by this office.

Shop plans, which are those plans drawn by the various contractors and submitted for approval.

Architectural Full-Size Detail plans of the various buildings.

Miscellaneous Foreign plans, which include plans of various works received from other offices.

The last three classes of plans, namely, the Shop plans, Architectural Full-Size Detail plans and Miscellaneous Foreign plans, are not numbered by this office, leaving the Office Record plans as the only plans bearing the file numbers, and for convenience of filing and handling, standard sizes for these plans were adopted as follows:

Record size	11 in. by 14 in.
Demy size	15 in. by 20 in.
Imperial size	23 in. by 31 in.
Double Elephant size	27 in. by 40 in.
Rolled plans to be made even feet in width and varying in length.	

Numbering and Filing of Data.

In numbering the Office Record plans, each size was given a separate series of 5 000 numbers, as follows: Record size, 10 000 to 14 999; Demy size, 15 000 to 19 999; Imperial size, 20 000 to 24 999; Double Elephant, 25 000 to 29 999; and Roll plans, 30 000 to 34 999. By this method a number of a plan indicates its size, and that, in turn, the size of the plan case in which it is filed, and this often enables one familiar with the office to find plans without consulting the card index.

Each size of the Office Record plans is classified and filed by subjects, such as " Column Foundations," " Land Takings," " Special Trackwork," etc. Each classification of each size of plans is given a sub-series of numbers within the limits of series corresponding to its size. The limits of these sub-series of numbers are determined by the number of plans that can be filed in the box, drawer or pigeon-hole, as the case may be.

Plans of the Record and Demy sizes are filed in boxes holding 100 tracings; those of the Imperial and Double Elephant sizes, in drawers holding 50 tracings; and the Roll plans in pigeon-holes containing 10 tracings each. Each box, drawer or pigeon-hole is of a separate classification, marked with its title and sub-series of numbers.

As before stated, the Shop plans, Architectural Full-Size Detail plans and Miscellaneous Foreign plans are not numbered by this office, but those pertaining to one piece of work are bound together and have a tag attached, stating to what work they refer, and are filed separately in a special case.

Loose-leaf plan catalogues titled, " Record plans," " Shop plans," " Architectural Full-Size Detail plans," and " Miscellaneous Foreign plans," contain the numbers, descriptions and any other identifying marks of all plans on file. It is from these catalogues that the plan index cards are written.

In numbering the field and computation books, each division of the work was given a separate series of 100 numbers, as, for example, Roxbury division, 500 to 599; Atlantic Avenue division, 600 to 699. By this system of numbering, the books can be readily separated into their respective divisions, which is very desirable whenever it becomes necessary to establish field offices along the line of work.

The photographic negatives are numbered in the same manner as the field and computation books, namely, by the geographical division of the work.

Field and computation book catalogues similar to the plan catalogue are kept, stating the nature of the contents of the books. Photographic negative catalogues, giving the number, date and description of the negatives, are also kept in the same form.

Indexing of Data.

The card indexes differ from many others only in the size of cards used, which is $8\frac{1}{2}$ in. by 7 in.

The plan index consists of blue header cards marked with the titles of the grand divisions of the plans, such as " Elevated

Steel Structure," "Passenger Stations," "Power Stations," "Track System," "Rolling Stock," "Power Transmission," "Car Houses and Repair Shops," etc., and white tab cards bearing numbers representing the subdivisions of these grand divisions. (Fig. 1.)

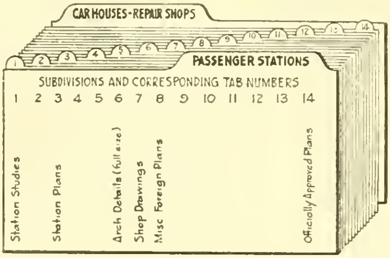

FIG. 1

On the blue header cards marking the grand divisions are found the titles of their subdivisions and their corresponding numbers. On the white tab cards bearing numbers indicating the subdivisions are found the description and location of the individual plans.

To illustrate the use of the plan index, take, for example, the grand division titled, "Track System," and we find upon the blue header card bearing this title some of the titles of the subdivisions and their corresponding numbers to be as follows:

No. 1, curve details; No. 2, track layouts; No. 5, special work; No. 7, shop plans; No. 8, foreign plans; No. 14, officially approved plans.

Suppose one wishes to find the shop drawings of some particular switch. Either at a glance, or by the process of elimination, one determines the grand division titled "Track System" as the classification including the plan sought. Upon the blue header card titled "Track System" is found among the titles of subdivisions that of "Shop Plans," which is numbered 7, indicating that the description of the shop plans of all track work is to be found upon the white tab cards numbered seven filed under the grand division of "Track System."

If the desired drawing is that of a switch of the Brooklyn Elevated instead of the Boston Elevated Railway, one would consult the tab cards numbered 8, which number corresponds to the subdivision of Foreign plans, as all plans of the Brooklyn Elevated Railroad are classified as Foreign plans. Again, if

one wished to know which plans of trackwork had been approved by the various city or state officials, he would find the information upon tab cards numbered 14, whose corresponding title is that of "Officially Approved Plans."

In the plan index, the same tab number is made to indicate the same subdivision under all the grand divisions as far as possible. For example, tab cards numbered 6 indicate architectural full-size details in all the grand divisions where applicable; number 7 indicates shop plans; and number 8 indicates miscellaneous foreign plans. By this method of using numbered tab cards to indicate subdivisions it is only necessary to consult those cards bearing the number representing the particular subdivision desired, and the handling of all others is, therefore, eliminated.

The computation book index consists of the same grand divisions, and is arranged in the same general manner as the plan index.

The field book index differs from the plan and computation book indexes in that street names alphabetically arranged appear on the blue header cards in place of the titles of the grand divisions. The numbers on the white tab cards which are filed under the blue header cards bearing the street names indicate the nature of the notes; for example, tab cards No. 1 always indicate survey notes; tab cards No. 2 always indicate level notes, etc., in place of the subdivisions of the plan index. (Fig. 2.)

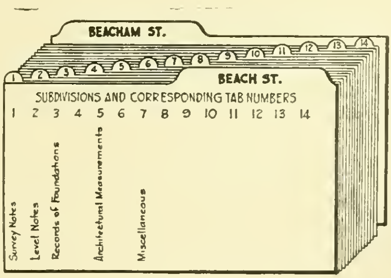

FIG. 2

The photographic negative index consists of loose-leaf books. The books are marked with the titles of the grand divisions of the plan index so far as applicable. In these loose-leaf books are inserted white fly leaves titled with the subdivisions of each book, and under each subdivision are filed blue prints of all

negatives belonging to that subdivision, chronologically arranged. For example, taking book titled "Passenger Stations," one will find upon the white fly leaves the names of all the various stations under which will be found chronologically arranged blue prints of all negatives taken showing that particular station from some time previous to construction to date of last negative taken. On these blue prints appear the number, date and a brief description of the photograph.

In preparing so-called subject indexes of this kind, it is important that the titles of the grand divisions be very carefully selected, so that there may be no doubt as to the grand division under which any plan belongs. Having the grand divisions well defined, the nature of the individual plans suggests titles of the subdivisions.

[NOTE. — Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by November 1, 1909, for publication in a subsequent number of the JOURNAL.]

PREPARATION OF PLANS AND THE ASSESSMENT OF BETTERMENTS IN BOSTON, AND THE LAWS COVERING THE SAME.

By Frank O. Whitney, Member Boston Society of Civil Engineers.

[Read before the Society, February 10, 1909.]

The laws relating to the laying out of streets and the assessment of betterments in Boston have been subject to various changes during the past twenty years.

Previously to 1891, streets were laid out by the Board of Street Commissioners, and assessments were levied at their discretion; their authority being prescribed by the general betterment law. In those days it was the practice to levy assessments only on improvements of large importance, in cases similar to the extension of Washington Street to Haymarket Square, and the widening and extension of Devonshire Street, and to leave the ordinary street laying out cost to be borne by the city.

In 1891 the Board of Survey Law was enacted, which provided that the whole cost of streets laid out under that act should be assessed upon the abutters. As that law did not repeal the general law, the board were still permitted to continue under the old law where the new one did not apply.

Later, the Board of Survey Law was amended, limiting the assessment to 50 per cent. of the cost, and in no case to exceed the real benefit.

In 1906, a new street law was passed for the city of Boston, providing that all streets should be laid out and assessed under it. This law was similar to the amended Board of Survey Law and is the one under which the city of Boston is now operating. It is the purpose of this paper to describe the details of its practical working. The law in detail may be found in the Acts of the Legislature of 1906, Chapter 393.

When a petition is received by the street commissioners, asking that a street be laid out as a public way, a plan is prepared showing the dimensions, width and grade of the proposed street. The plan also shows any parcels of land to be taken in such detail that deeds may be made of each ownership. All buildings and fences are shown in plan and profile with sufficient accuracy to estimate any damages occasioned by either line or grade.

If the Board of Street Commissioners are of the opinion that

the improvement should be made, whether consisting of the laying out, relocating, altering, widening or discontinuing, with or without construction of sewer, or of changing the grade, or constructing with or without sewer, they appoint a time for a public hearing, and cause a notice of the same to be published twice a week for two successive weeks in two daily papers published in the city, the last publication to be at least seven days prior to the time fixed for the hearing.

After the hearing the board may pass an order for making the improvement. At the same time the board pass another order, in which they determine and award the damages to be paid by the city to each person whose property is taken for the improvement.

These orders are null and void unless they shall be approved in writing by the Mayor within three months after first publication of the notice; and if so approved they are recorded in the records of the board, take effect and are carried out. After the approval by the Mayor, the order for the improvement is recorded in the Registry of Deeds. Any person dissatisfied with the award has recourse to the Superior Court.

The superintendent of streets is authorized to carry out the orders of the Board of Street Commissioners in the manner prescribed in sections three and four of the law.

At the time of passing the order for the improvement, the board estimates the probable benefit to each parcel of real estate, any part of which lies within 125 ft. of the improvement, beyond the general advantage to all real estate in the city. For this purpose a plan is prepared showing all estates within the assessable area.

Within two years after the completion of the improvement the board are required to determine the actual benefit to each parcel and determine the assessable cost. If the benefit warrants the same the board may assess one half of the cost upon the property benefited, but in no case shall the amount assessed exceed the original estimated benefit.

In making up the cost there are excluded the cost of sewers above $4. per linear foot, all surface drainage, water pipes and gas pipes.

These assessments may be paid in full or divided into ten annual installments with interest. Assessments and damages bear interest at 4 per cent. per annum: in the case of damages, from the date of taking; and for assessments, thirty days after

the assessment is made. The assessment becomes a lien upon the property from the date of the first advertisement.

No person has a right to open a private way for travel in the city of Boston unless its location, direction, width and grades have been approved by the Board of Street Commissioners and the Mayor.

All city departments are prohibited from placing any public work of any kind in any way opened contrary to law.

As an illustration of the method of procedure, I have selected the case of Oakridge Street, Dorchester, as a typical street containing all the conditions ordinarily met with. This street existed as a private way leading from Morton Street. The Board of Street Commissioners laid out this street and extended it through private land to Codman Street.

This work was the result of a petition to the board signed by a large number of interested parties.

Upon the receipt of this petition, the commissioners caused a plan to be prepared showing the direction, width and grade of the proposed improvement, together with the relation of the abutting property to the same, with sufficient information to show the grade damages and amount of land to be taken.

An order of notice was then issued, September 12, 1906, setting September 26, 1906, as a date for a public hearing. This notice was duly advertised four times in two daily papers published in the city of Boston.

As a result of the hearing, the Board of Street Commissioners passed the order for the laying out of the street, October 5, 1906, which was approved by the Mayor, October 17, 1906.

This order and a copy of the plan was recorded in the Suffolk County Registry of Deeds, October 23, 1906, and the way became a public street.

Simultaneously with the passage of the order an estimate of the damages incurred and the estimated benefit to parties concerned was transmitted to the Mayor for his approval. The damages were estimated from data shown on the plan and an inspection of the ground. The estimated benefit was apportioned from data shown on a plan prepared for the purpose. The estimated expense was made up by adding the amount of damages allowed by the board and an estimate of the cost prepared by the superintendent of streets; viz.: $1 075.50 and $8 800, making a total of $9 875.50. The statement of the superintendent of streets was furnished upon request of the board previously to any public action.

The street was then turned over to the superintendent of streets to construct, and the damages were settled by the Board of Street Commissioners.

After the completion of the street the superintendent of streets certified to the actual cost, this amount, $7 771.71, together with the damages paid, $1 075.50, totaling $7 946.21, being the cost of the improvement. Fifty per cent. of this amount, or $3 973.60, became the assessable cost.

The board then proceeded to assess upon the interested parties such amounts as in their judgment were warranted by the benefit, which in this case was a little less than 50 per cent. of the cost.

I have discussed only the working of the Boston law, as that is the only one under which the city is authorized to operate; but I think the general law as applied to other cities is different only in a few details, the essential working of which is practically the same.

The following table gives the number of streets assessed for ten years from 1897 to 1906 inclusive, together with the cost and assessment.

ASSESSMENTS.

Year.	Streets.	Cost.	Assessment.	Special Betterments.
1897	5	$47 741.84	$47 741.84	
1898	7	81 465.85	60 367.69	$367 440.00
1899	8	81 520.32	76 273.84	
1900	27	399 010.27	330 376.15	1 387 512.79
1901	11	44 265.43	36 281.96	
1902	55	1 887 353.30	593 433.09	
1903	33	*2 461 559.46	797 302.53	
1904	25	323 285.19	127 703.88	
1905	34	522 238.10	165 831.17	
1906	6	542 737.38	81 851.43	
	211	$6 391 177.14	$2 317 163.58	$1 754 952.79
Reassessed,		*268 354.11	236 027.56	338 878.52
		$6 122 823.03	$2 081 136.02	$1 416 074.27

[NOTE. — Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by November 1, 1909, for publication in a subsequent number of the JOURNAL.]

Editors reprinting articles from this JOURNAL are requested to credit the author, the JOURNAL OF THE ASSOCIATION, and the Society before which such articles were read.

ASSOCIATION OF ENGINEERING SOCIETIES.

Organized 1881.

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WORK OF COMPLETING CHALMETTE MONUMENT.

BY ALFRED F. THEARD, MEMBER LOUISIANA ENGINEERING SOCIETY.

[Read before the Society, June 14, 1909.]

ABOUT three years ago, at the request of one of my personal friends and of the ladies who form the membership of the United States Daughters of 1776 and 1812, I made an investigation of the then existing conditions at the Chalmette Monument. I studied closely the conditions under which the work had been planned and partly executed, and thereafter submitted a written report covering the result of my investigation and making some suggestions as to the continuance of the work. These suggestions were submitted to and approved by these ladies. I never even suspected at the time that I was about to put myself in a peck of trouble.

What I had done was done because of my sympathy with those who were striving to make this momument a fitting tribute to the memory of the heroes of 1815, and I felt honored to have been called upon to help along this good cause. But the friendship of the gentleman who had spoken to me made him look upon my work as through a magnifying glass, and he so impressed the ladies with the importance of my suggestions that my report was used as one of the documents to solicit federal aid and to support the strong case admirably presented to Congress by their association. Within fourteen months after the first investigation, I think in March, 1907, Congress appropriated the sum of $25 000 to cover the entire cost of the improvement recommended. The victory which was won proved the influence of the distinguished

ladies who had helped this cause, had gone to Washington, appeared before the committee of Congress, and, by an eloquent appeal, obtained a favorable report and finally secured this appropriation which made the work possible.

Some few months later, in June, 1907, I was agreeably surprised and very highly flattered when Major McIndoe, on behalf of the Secretary of War, asked me to prepare plans and specifications for the work contemplated under my original suggestions, and fixed the terms of my compensation for professional services.

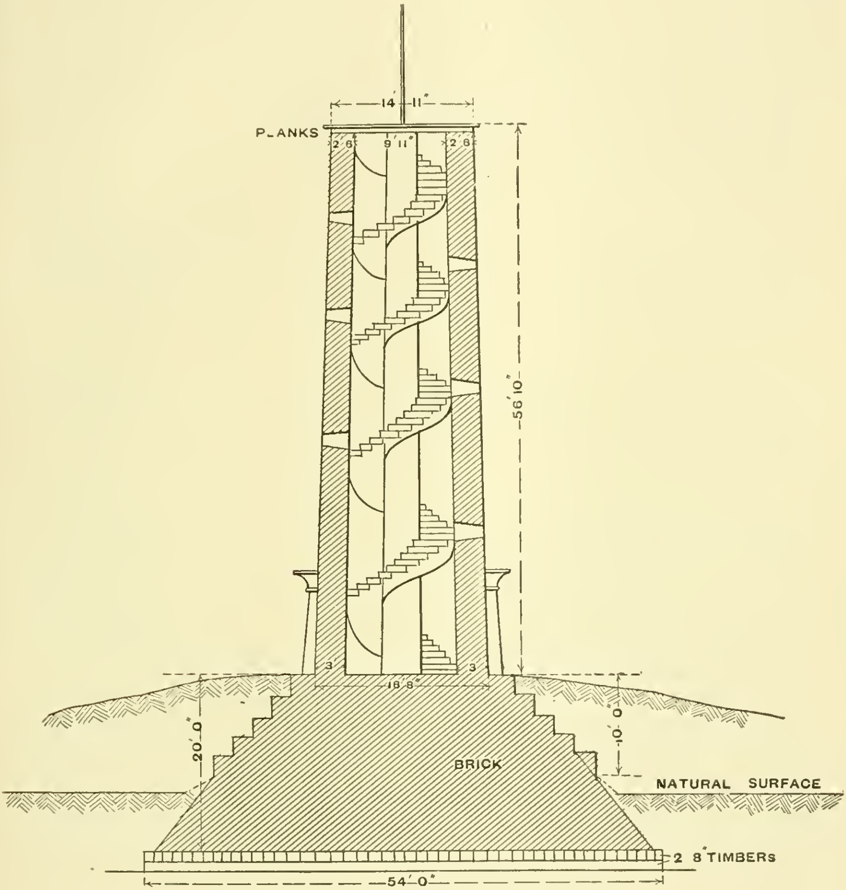
About the first of July, I commenced a thorough investigation of the actual conditions at the monument. Considering it absolutely necessary from a professional standpoint, I had, at my own expense, excavations made, and exposed the entire west side of the foundations down to the bottom. I desired to ascertain the exact condition of these foundations before attempting to increase the load then carried. Of course I felt reasonably safe, because this unfinished shaft, built within a few hundred feet from the river, had withstood the fury of the elements for over fifty years, — quite a severe test, particularly for the parts exposed to the weather. And if any signs of settlement were apparent, they were so slight that they need not be considered.

Many of you know how the Chalmette Monument was originally designed by Newton Richards; how his plans were adopted by the Jackson Monument Association in May, 1855; and how a contract for the erection of the monument was awarded to Newton Richards and John Stroud & Co., in June of the same year.

The designs submitted, the original being at present in the notarial archives in this city, covered four distinct plans numbered from "1" to "4" inclusive, graded in cost and finish from an expensive and elaborate monument nearly 200 ft. in height to a plain column barely 60 ft. high; the one being of proportionate size and finish, with an ornamental capital; the other being devoid of any ornamentation, with a bare and simple appearance.

The design selected (marked "2" on the original plan), while less elaborate and expensive than the most costly, was undoubtedly, in my opinion, the most appropriate and the most beautiful. It consisted of a plain shaft, 142 ft. high, resting on five steps, each 2 ft. high, and starting about 2 ft. 6 in. above the natural surface of the ground; the shaft to be 16 ft. 8 in. square at the base, and 12 ft. 6 in. at the top; the base of the shaft on the four faces to have corniced projections surmounted with

sculptured emblems; one of these to serve as an entrance to a spiral stairway leading to a chamber at the top; the stair being lighted by small openings at regular intervals; both shaft and base to be faced with marble.



SECTION OF MONUMENT AS IT WAS.

The work had been partly erected, and a careful examination confirmed me in the belief that what was done had been done in accordance with the specifications annexed to the original contract, and with a view of the carrying out of the work as originally contemplated. Indeed, the foundations, as specified, were to consist of a double floor of 8-in. timbers laid transversely 54 ft. square; then a thickness of 20 ft. of brick work, 53 ft. square diminished by gradual offsets of 2 ft. 6 in. each, at every

2 ft. above the natural surface, to a square of 22 ft. at a point 3 in. below the marble facing of the shaft.

I copy the original specifications for this item:

A flooring of timber is to be laid in the bottom of the excavation to start the brickwork upon. It is to be 54 ft. square, formed of two courses of sound timbers, each to be 8 in. thick, one course to be laid transversely across the other and to be fastened at every alternate crossing, both courses, with tree nails of $1\frac{1}{2}$ in. diameter. The pieces of timber all to be straight, laid close together and thoroughly rammed down to a solid, even and level bearing and the joints, interstices if any, thoroughly filled with mortar in each course as it is laid. The cross timbers will be laid under the longitudinal timbers on one side and upon them on the opposite side of the foundation, so that the long timbers may all cross each other at all the four corners of the foundation. The timbers to an extent of 12 ft. square in the center of the floor are to be disconnected from the surrounding ones.

I have read this particular description because I wanted you to note the peculiar provision for any future movement or settlement by this independent platform, 12 ft. by 12 ft., in the center of the square area.

The shaft was 56 ft. 10 in. above the line at which the top of the step would meet it; this step or base being, if completed, about 12 ft. 6 in. above the natural surface. From the natural level to this point, a mound extended around the base of the monument, with a diameter of about 185 ft. At the foot of the mound was a ditch which drained the entire plot. At the top of the shaft the very crude wooden cover (an ordinary flooring on five pieces of 4 in. by 12 in. laid crosswise) showed conclusively that neither the designer nor the Jackson Monument Association ever intended to leave the work at this point. The large mound which covered the entire base had been placed there, a few years before 1906, not to form part of the ultimate structure, but merely to serve as a protection for the uncompleted base, and no doubt accomplished its purpose.

I was pleased to find the foundations in a perfect condition. The timbers were in a remarkable state of preservation and now, nearly two years since they were secured, I have here for your inspection a few chips taken from these timbers which I consider quite interesting. Some of those who have examined these samples have differed as to whether they are cypress or pine. I believe they are good cypress.

The first two or three courses of brick had been exposed to the weather for a long time before the mound was placed over

them and the mortar was either entirely removed from the joints or crumpled into a soft powder, but when these three outside courses were removed the brickwork was in a perfect condition. The marble facing of the shaft was very much soiled from its long exposure to dust and rain. The visitors to the Chalmette Monument, perhaps through a desire of becoming famous by their close, very close, association with this monument, or probably through their craving for the slow destruction of all monuments, — these visitors, numbering hundreds of thousands, were responsible for the miserable condition of the interior of this historic shaft.

Using 108 lb. per cu. ft. of masonry, and 50 lb. per cu. ft. of timber, I figured that the foundations carried a load of nearly 2 000 tons, or about 1 350 lb. to the square foot, exclusive of the wedge of dirt which formed the mound. I estimated that I would add approximately not over 200 lb. per sq. ft. to the load, and I concluded that this was perfectly safe under the conditions found. The total load actually carried is 4 375 000 lb. or very nearly 1 500 lb. per sq. ft.

As soon as I had completed the plans for the new work, these were approved by the Secretary of War, now our respected President, W. H. Taft, and bids were invited. The contract was awarded to Mr. M. P. Doullut, a local contractor, work started about January, 1908, and was completed at the end of the year.

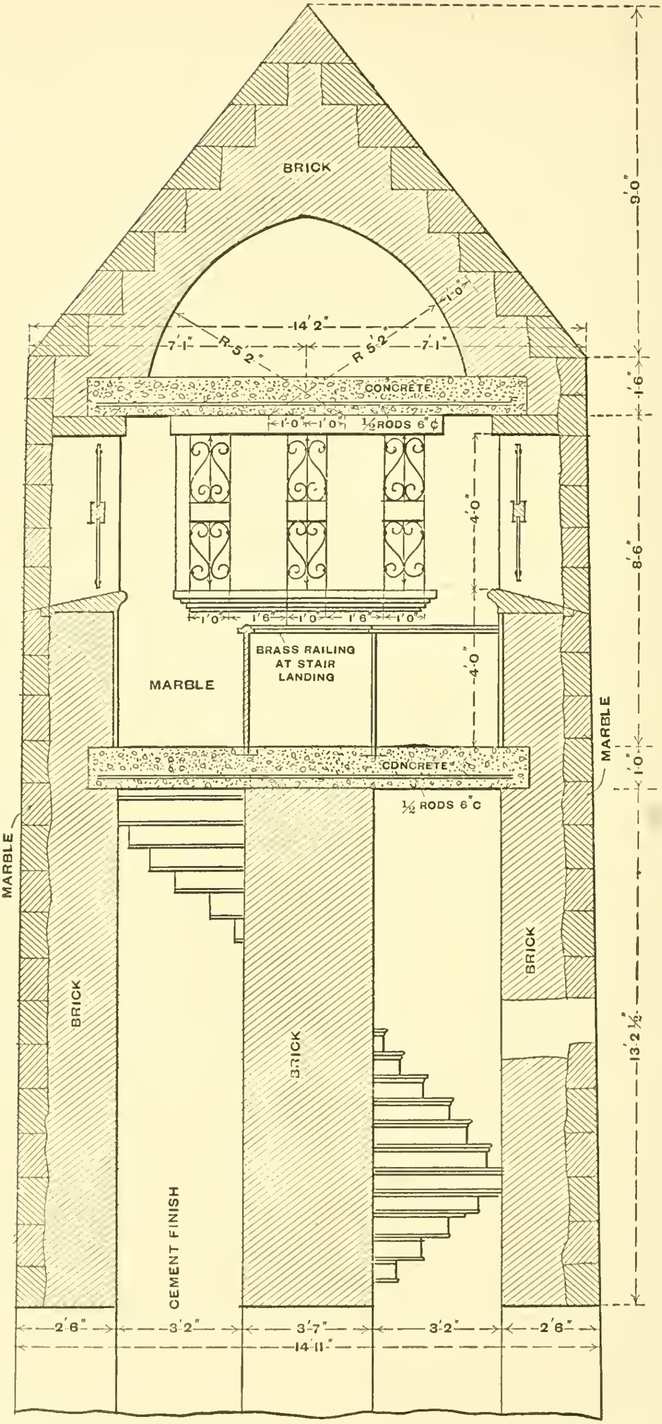
The work was accepted by the United States Government through Lieut.-Col. Lansing H. Beach, in charge of the local engineering office, and the maintenance of the monument was placed in the hands of the local chapter of the United States Daughters of 1776 and 1812, to conform to the act of Congress.

The evolution of the monument from an old brick pile to the present imposing structure is exhibited by the illustrations accompanying this paper.

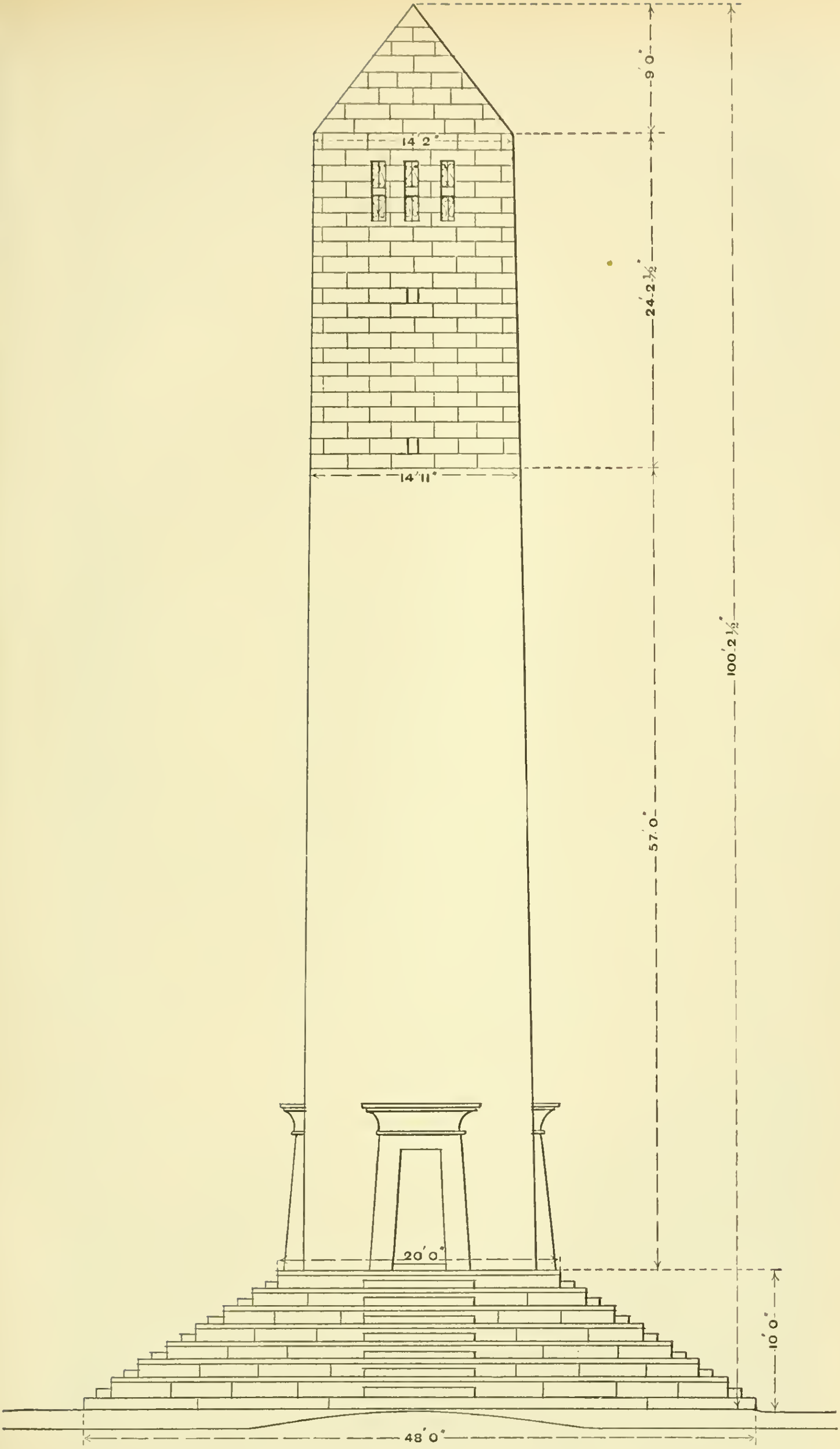
As to the total cost of the work as it stands to-day, I can only estimate it. The original contract was for $57 000; but I suppose, as the work was only partly done, about $40 000 is fair to assume as the original cost. This added to the last appropriation of $25 000, which was entirely absorbed, would bring the total to $65 000.

For a general description of the work, it is better to read a few paragraphs of the specifications (which were carried out to the letter).

18. *Character of Work.* The work to be done consists in the removal of the mound of earth covering the base of the



New Work, Section on Center Line of Shaft.



FRONT VIEW, SHOWING NEW WORK.

existing monument, the extension of the shaft on the present lines 24 ft. $2\frac{1}{2}$ in., and the covering thereof, at that point, by a pyramid 9 ft. high, making the entire structure, when completed, approximately 100 ft. above the natural level of the ground. [Actual height, 100 ft. $2\frac{1}{2}$ in.]

19. *Order of Work.* The order in which the work should be prosecuted is: (1) Completion of the shaft and pyramid; (2) cleaning and retouching the entire shaft; (3) removing the mound of earth at the base; (4) completion of the base. This order will remove any chance of tarnishing or spoiling new work, but the contractor will be allowed, with the approval of the engineer, to prosecute the work in any order which he may find suitable and to meet advantageously the time of delivery of material on the ground. [Order of work was observed.]

21. *Brickwork.* At the top of the existing brickwork a sufficient number of brick shall be removed, at intervals, to form slots so that the new and old brick work shall be well bonded. When this is done to the satisfaction of the engineer, the present brickwork will be continued, as shown on the plans, up to the base of the pyramid, care being taken to fill up with brick and mortar all rough surfaces on the rear of the marble facing so as to form a compact mass when finished. At a point in the plane immediately above the cap of the windows in the observation chamber (all as shown on drawings), and with centers as given, a cone-shaped form of timber must be built to act as a support for the brick arch which forms the pyramid. Great care will be taken in laying this brickwork to form a substantial arch, as it is essential that this work be first class in every respect.

Sufficient brick must also be removed from the base of the monument to insure a good bond between old and new work and to allow the top of the marble facing to conform to the plans. All bricks used, both in shaft and base, must be good quality, hard, sound Lake bricks. They must be properly moistened with water when laid and solidly bedded in mortar. All joints will be shove joints perfectly filled. All necessary and proper bonds, ties, anchors, rabbets, recesses, jambs and openings will be finished and completed as the work progresses to conform to the plans.

22. *Marble.* The marble used in the existing monument is what is known as the Tuckahoe marble, presumably quarried in the state of New York. It is essential that the marble to be furnished for completing the monument match as perfectly as possible the marble formerly used. Bidders must, therefore, furnish samples of the marble they propose to use and any marble which, in the opinion of the engineer, does not meet the above requirements will be rejected. [Second-hand Tuckahoe marble quarried about same time was used.]

23. *Marble Work.* The entire exterior surface of the base, shaft and pyramid will be of marble ashlar, not less than 3 and 6 in. thick, respectively, for the base and shaft as shown. The ashlar facing of the shaft will be from 3 to 5 and 8 in. thick, as it may happen in quarrying, the thin and thick courses to be placed

The Completed Monument.

alternately, so as to form a bond with the brickwork, and to be laid up battering on the face according to the drawings, the shaft being 16 ft. 8 in. wide at the base and 14 ft. 2 in. at the top. The beds of the ashlar must be all cut to a perfectly horizontal line. Every piece in each alternate course of ashlar is to be securely cramped to the brickwork with cramps 1 ft. long, $\frac{1}{4}$ by $1\frac{3}{8}$ in. flat iron bars, let into the marble 2 in. and turned on the brickwork 3 in. and covered in the marble with proper sand and cement. All of the marble ashlar for the shaft and pyramid is to be tool and tooth finished to match the present finish. The ashlar for the face of the base course, both horizontal and vertical, is to be 6 in. thick, with proper dowels and cramps, and all courses are to be laid to a perfect horizontal line. All the exposed surfaces of the marble work in the base are to be sand finished.

The present facing is to be removed as far down from the top as may be necessary to restore the facing to its proper alignment, and to permit the refilling of the joints which have been cracked and destroyed by vegetable growth. All missing or broken pieces of facing or broken corners or projections over openings are to be replaced where necessary, and the joints refilled.

24. *Marble Steps*. The exterior steps, as shown ascending the base of the monument on the four sides, are to be solid blocks of marble, 8 in. by 12 in. by 8 ft. Dowels and cramps for the steps are to be of copper, $\frac{3}{8}$ in. thick.

25. *Marble Veneer*. The four walls of the observation chamber at top of monument shall be covered with a polished marble veneer not less than 1 in. thick and properly fastened to the brickwork. The marble caps and sills for the lookouts or openings in the observation chamber shall be carried out as shown on the drawings.

Iron steps were continued to the floor of the observatory or chamber, which is lined with panels of Georgia marble, and has twelve bronze grilled openings with a glazed sash.

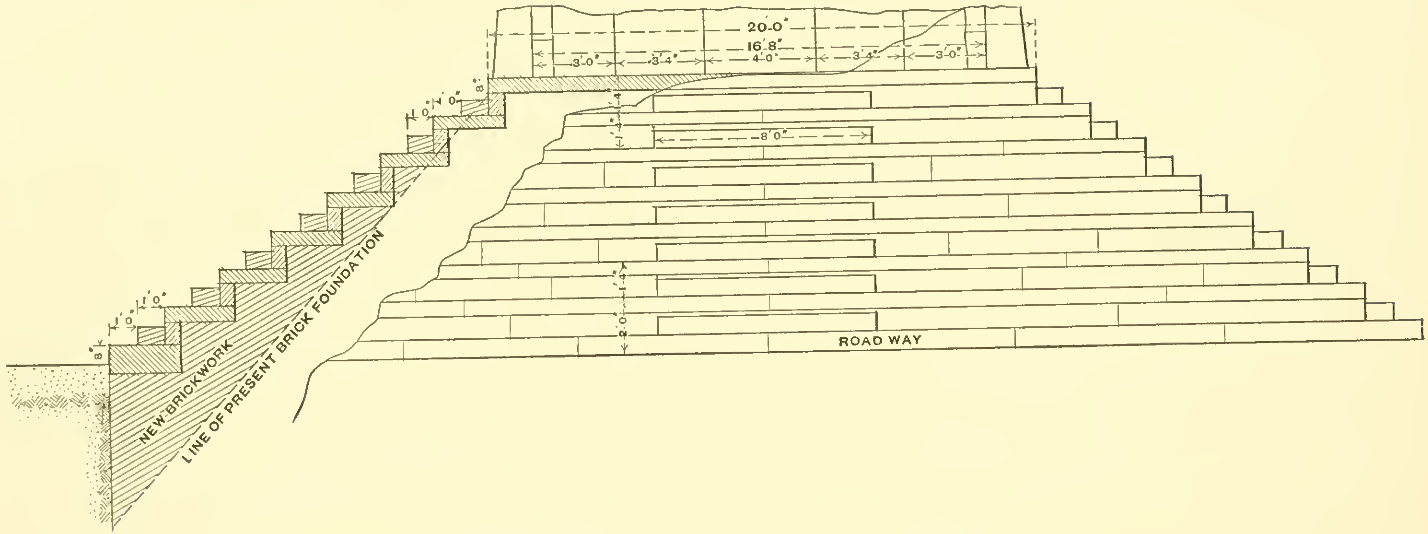
The entrance has a heavy bronze door.

A bronze tablet placed inside of the monument is inscribed as follows:

"Monument to the memory of the American soldiers who fell in the Battle of New Orleans at Chalmette, Louisiana, January 8th, 1815.

"Work begun in 1855 by Jackson Monument Association.— Monument placed in custody of United States Daughters of 1776 and 1812 on June 14th, 1894 — Monument and grounds ceded unto the United States of America by the State of Louisiana on May 24th, 1907 — Completed in 1908 under the provisions of Act of Congress approved March 4th, 1907."

No definite plans have as yet been worked out for improving



Part Elevation and Section of Base as Altered.

the surroundings and approaches to the monument. It would be proper, if land could be secured, to have a roadway about 100 ft. wide connecting the monument plot with the Chalmette Cemetery. If no land is acquired, a proper driveway lined on both sides with artificial stone walks should connect the public road with the monument; that, of course, would be on the present plot.

In closing these remarks, I will say that the work was done well, and, in my opinion, the monument, so far, is completed in a fit and appropriate way, and that it will forever be a credit, not only to those who have planned and designed it; not only to those who have generously contributed to its erection; not only to him in whose honor it was erected, the gallant and respected American, Andrew Jackson; not only to those who have lost their lives in the great battle which it commemorates; but that it will, as well, become the pride of these good ladies, who, by their indefatigable zeal, patriotism, devotion and respect for the achievements of their forefathers, succeeded in getting this great monument completed after it had been abandoned and nearly forgotten.

[NOTE. — Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by December 1, 1909, for publication in a subsequent number of the JOURNAL.]

DISCUSSION OF MR. FLETCHER'S PAPER, "THE FIRST INTERNATIONAL ROAD CONGRESS."

(Vol. XLII, Page 200, April, 1909.)

Mr. L. F. Patstone. — In reviewing the proceedings of the "First International Road Congress," held at Paris in October, 1908, it would seem that there had been too much generalization and not sufficient specific information of processes and results.

The most effective accomplishment of this Congress was the impetus it gave to a more general exchange of ideas along the various lines of road construction than has obtained heretofore and the provision for the Second Road Congress to meet at Brussels in 1910.

A few of the papers seem to disclose the proneness of their authors to get upon the house-tops and shout, "I did it," without telling how or giving the important facts in the cases. The idea seems to have been lost sight of that a congress of this nature is supposed to get down to the cold unvarnished facts and present them in a concise form from which may be obtained *Results*.

Merely to bring out a more general discussion of the progress being made in roads and pavements, the writer intends setting forth what he believes should be taken into consideration in working out standards for road construction.

The first points to be considered in determining the character of construction are, climate, character of traffic, character of soil and contour of country. Under climate should be considered the amount of rainfall or melted snow per year and the maximum and minimum periods of their occurrence. The maximum and the minimum temperature should be gone into, and the approximate periods over which they extend determined.

The character of traffic should be considered under the headings of rural, suburban and city. The number of ton miles per hour and per day, together with the maximum and the minimum loads, should be determined. The season of maximum and minimum traffic, the class and the rate of speed, together with the character of the tires, should also be determined.

The character of soil, such as imperviousness, height of ground water in relation to road foundation and minimum bearing power of the soil should be investigated.

The contour of the country, the maximum and the minimum grade and the radius of curvature in changing direction should be considered.

From the data as above outlined may be determined the thickness of the foundation, the character of the wearing surface, the cross section of the road and the method of maintenance. An important factor in determining the thickness of the foundation is the bearing power of the soil. The construction of a table having legs composed of 12 in. by 12 in. stock to be used in determining the bearing power of poorer soils will be found effective The table is to be placed over a portion of the ground previously saturated with water and then loaded with pig-iron until failure results, or a figure obtained for the minimum bearing value. With this bearing value the thickness of the road may be obtained by taking the maximum wheel load and assuming that it is carried down through the foundation at an angle of 45 degrees. If we let D equal the required depth, W the wheel-load and B the bearing power of the soil we derive, $D=\sqrt{\frac{W}{4B}}$. A safe depth for the foundation may now be found by subtracting one half of the thickness of the wearing surface from the total thickness of the road just determined.

The character of the traffic and the relative cost of available material, together with the cost of maintenance, should be carefully gone into in selecting the wearing surface. The question of sanitariness, ease of cleaning and fitness for the locality are also points that may have to be considered.

The question of the cross section depends largely on the character of the wearing surface. The crown should be such as to carry off the water without injuring the surface. It should also carry it off quickly enough to prevent the possibility of freezing before reaching the sides.

The foothold for horses and the setting of vehicles on the road are points to be kept in mind. There appears to be a tendency in working out the crowns of roads, and also pavements, to deduce the equation of some curve or to make the ordinates a certain proportion of the total rise, losing sight of the fact that the foothold for horses is a factor in determining the crown. The writer recalls an instance on a smooth pavement where the crown at the different points was made dependent on a certain proportion of the rise, and as a result the rate of rise at the sides of the street was between 5 or 6 per cent., and, as was to be expected, trouble was experienced from horses falling on this pavement.

The width of roadway and the thickness of the wearing surface are dependent on the character of the locality through which the road passes and the amount and character of traffic. For rural communities, where the traffic is at a minimum, the roadway may be only 12 ft. in width, and in communities where the traffic increases to such an extent as to occasion a great deal of passing, the width should not be less than 16.5 ft.

The character of maintenance is nearly as important as the first construction. The success or failure of any system, however, is dependent on the superintendence.

The point as to whether the money shall be raised by direct or indirect tax, or the labor performed by contract, local labor working out the taxes, or regular skilled employees, is not so important as the one of competent skilled superintendence. Standard construction, proper machinery and tools and experienced supervision are the requisites for successful roads. (Under these conditions the number of men per mile and the amount allowed per mile per year will be brought to a reasonable figure.)

The following classes of road construction appear to the writer to be fitted for the peculiar service required of them.

Road for Vehicles of Slow Speed. — Width of roadway from 12 ft. to 16.5 ft., with additional 4 ft. on each side for slope to shallow gutter. Grade from center to sides not less than 4 per cent. Sub-grade, thoroughly rolled by road roller of not less than 10 tons. Thickness of foundation dependent on bearing power of soil when saturated with water. In soils having a bearing power of 1 000 lb. the thickness of the foundation should not be less than 9 in. This thickness will gradually decrease so that a bearing power of 4 000 lb. will be sufficient to insure good results without a foundation. Upon this foundation should be laid a 3-in. course of 2½-in. stone. This course should be sprinkled and rolled at the rate of 500 sq. yd. per hour. The 3-inch top course of 1½-in. stone should then be added and should be sprinkled and rolled at the rate of 100 sq. yd. per hour. Stone dust and screenings should then be added and the surface thoroughly flushed, brooms being used to work the binder into the voids. The road should not be opened to traffic for at least five days after completion, and should be kept sprinkled for at least ten days.

It may be contended that the thickness of the foundation is excessive, but the writer has found that such a thickness is economical and that a district where the thickness of the founda-

tion has been determined from the bearing power of the soil will have good roads to show at the end of a given period, whereas at the end of the same period in a section where little or no attention has been paid to the foundation there will be nothing to show but bad roads or apologies for roads for equal expenditure.

Country Road for Vehicles of Slow and High Speed. — Width of roadway not less than 16.5 ft., with additional 4 ft. on each side for slope to shallow gutter. Foundation same as that described under "Country Road for Vehicles of Slow Speed." Upon this foundation place a 4-in. layer of broken stone of sizes ranging from 2 in. to 3 in. Roll this layer at the rate of 300 sq. yd. per hour and then flush over the surface a mixture of 2 parts coal tar, 1 part pitch and 1 part asphalt, applied at a temperature of 150 degrees fahr. and at the rate of 0.8 gal. per square yard.

Upon a platform provided for the purpose spread a layer of stone ranging from ½ in. to 1½ in. in size and coat same with a mixture of 1 part asphalt and 1 part coal tar, using at the rate of 22 gal. per cubic yard. Spread this on the previously laid portion to a depth of 3 in. and roll same until thoroughly compacted. Allow this to stand 24 hr. and then flush the surface with a mixture of 1 part asphalt, 1 part pitch and 1 part coal tar. Immediately spread a layer of clean, dry, sharp sand. Let this stand for a day and then roll. Roll the section slightly every day for a period of five days and then open to traffic.

Treatment of Existing Macadam Roads to Fit Them for Fast Moving Self-Propelled Vehicles. — Loosen up the surface of the existing macadam by using picks in the road roller wheel. After the road has been picked sufficiently, use a harrow to still further loosen the surface. The roller can be used to pull the harrow, care being taken that the chain used for hauling is of sufficient length and so connected as to prevent the necessity of the roller having to pass over the portion previously harrowed. Any soft places that may develop should be excavated and filled with broken stone. After this surface has been brought to proper cross section, flush the same with coal tar heated to 150 degrees fahr., using at the rate of ½ gal. per square yard. This material may be either spread by the use of dipper, may be flushed on from a hose attached to the heating tank or from one of the patented spraying machines. Allow the surface to stand 24 hr. and then spread a 1-in. layer of ¼ in. to ½ in. stone chips coated with a mixture of 1 part asphalt and 1 part coal tar, using at the rate of 22 gal. per cubic yard. Roll with a 10-ton roller at the rate of

300 sq. yd. per hour. Allow to stand for 24 hr. and then flush over the surface a mixture of 1 part asphalt, 1 part pitch and 1 part coal tar. Immediately spread over the surface a layer of clean, dry, sharp sand. Let this surface stand for a day and then roll. Roll slightly every day for a period of five days and then open to traffic.

In the use of coal tar, pitch and asphalt certain precautions are necessary to insure good results. Before any work is started an analysis of the material to be used should be made; in fact, as much precaution should be taken as is observed in determining the character of cement which is to be used in any large engineering construction.

Especial care should be used with the coal tar to see that the loss of volatile matter does not exceed 7 per cent. when kept at a temperature of 120 degrees for 6 hr. In heating the mixture every precaution should be taken to prevent burning. This is often one of the principal causes of failure.

In concluding, the writer wishes to suggest a few points to be taken up by the next International Road Congress.

1. Standard cross section for roads of various classes of traffic.

2. Thickness of foundation necessary for various classes of soil and traffic.

3. Specifications for coal tar, pitch and asphalt.

4. Machinery for mixing and applying bitumen.

5. General road machinery.

6. Specific data giving point by point the methods to be followed in the various types of road construction.

7. Data covering pavements for heavy traffic.

8. Include in the proceedings the question of pavements for city streets.

9. Wheel and tire ordinance.

DISCUSSION OF PAPER BY S. BENT RUSSELL, "NOTES ON CERTAIN POINTS IN THE DESIGN OF LARGE FILTRATION PLANTS."

(VOLUME XLII, PAGE 323, JUNE, 1909.)

MR. E. G. MANAHAN. — In determining the capacity of wash water devices for large mechanical filtration plants, the author neglects two essential factors. *First*, extra capacity must be provided because filters should not be washed in regular rotation at equal intervals of time, but, in order to prevent loss of filter capacity, must be washed whenever washing becomes necessary. *Second*, spare capacity must be provided, not only for times of cleaning and minor repairs of the pumps, but also for times when a pumping unit must remain entirely out of service for repairs for a number of days. Neglect of these factors means failure.

Furthermore, the author's illustration, in which he assumes 3 gal. as the number of gallons of wash water required per 100 gal. of water filtered with worst water, is misleading. Three gallons is about an average figure. The maximum should be assumed at not less than 5 gal.

The author apparently criticises the wash water capacity of the Cincinnati plant. After noting that the capacity of the pumps is only 2 500 gal. per minute each, and making proper assumptions and allowances, as above, it is, however, seen that the Cincinnati pumps are too small rather than too large. Space and connections are provided at Cincinnati for the installation of an extra pump if needed in the future.

The additional flexibility and certainty of operation obtained by providing a wash water reservoir of a capacity greater than one washing in most instances justifies its extra cost, which is an extremely small percentage of the cost of the whole plant. Where, as at Cincinnati, the reservoir performs other important functions besides the storage of wash water, the provision for a storage only equal to or less than the volume of one washing, as the author seems to recommend, would be extremely inadvisable.

ASSOCIATION OF ENGINEERING SOCIETIES.

Articles of Association Adopted December 4, 1880.

For the purpose of securing the benefits of closer union and the advancement of mutual interests, the engineering societies and clubs hereunto subscribing have agreed to the following Articles of Association.

ARTICLE I.

NAME AND OBJECT.

The name of this Association shall be the "Association of Engineering Societies." Its primary object shall be to secure a joint publication of the papers and transactions of the participating societies.

ARTICLE II.

ORGANIZATION.

Section 1. The affairs of the Association shall be conducted by a Board of Managers under such rules and by-laws as they may determine, subject to the specific conditions of these articles. The Board shall consist of one representative from each society of one hundred members or less, with one additional representative from each additional one hundred members, or fraction thereof over fifty. The members of the Board shall be appointed as each society shall decide, and shall hold office until their successors are chosen.

Sect. 2. The officers of the Board shall be a Chairman and Secretary, the latter of whom may or may not be himself a member of the Board.

ARTICLE III.

DUTIES OF OFFICERS.

Section 1. The Chairman, in addition to his ordinary duties shall countersign all bills and vouchers before payment and present an annual report of the transactions of the Board; which report, together with a synopsis of the other general transactions of the Board of interest to members, shall be published in the Journal of the Association.

Sect. 2. The Secretary shall be the active business agent of the Board and shall be appointed and removed at its pleasure. He shall receive a compensation for his services to be fixed from time to time by a two-thirds vote. He shall receive and take care of all manuscript copy and prepare it for the press, and attend to the forwarding of proof-sheets and the proper printing and mailing of the publications. He shall have power, with the approval of any one member of the Board, to return manuscript to the author for correction if in bad condition, illegible or otherwise conspicuously deficient or unfit for publication. He shall certify to the correctness of all bills before transmitting them to the Chairman for countersignature. He shall receive all fees and moneys paid to the Association and hold the same under such rules as the Board shall prescribe.

ARTICLE IV.

PUBLICATIONS.

SECTION 1. Each society shall decide for itself what papers and transactions of its own it desires to have published and shall forward the same to the Secretary.

SECT. 2. Each society shall notify the Secretary of the minimum number of copies of the joint publications which it desires to receive, and shall furnish a mailing-list for the same from time to time. Copies ordered by any society may be used as it shall see fit. Payments by each society shall, in general, be in proportion to the number of copies ordered, subject to such modification of the same as the Board of Managers may decide by a two-thirds vote to be more equitable Assessments shall be quarterly in advance, or otherwise, as directed by the Board.

SECT. 3. The publications of the Association shall be open to public subscription and sale, and advertisements of an appropriate character shall be received under regulations to be fixed by the Board.

SECT. 4. The Board shall have authority to print with the joint publications such abstracts and translations from scientific and professional journals and society transactions as may be deemed of general interest and value.

ARTICLE V.

CONDITIONS OF PARTICIPATION.

SECTION 1. Any society of engineers may become a member of this Association by a majority vote of the Board of Managers, upon payment to the Secretary of an entrance fee of fifty cents for each active member, and certifying that these Articles of Association have been duly accepted by it. Other technical organizations may be admitted by a two-thirds vote of the Board, and payment and subscription as above.

SECT. 2. Any society may withdraw from this Association at the end of any fiscal year by giving three months' notice of such intention, and shall then be entitled to its fair proportion of any surplus in the treasury, or be responsible for its fair proportion of any deficit.

SECT. 3. Any society may, at the pleasure of the Board, be excluded from this Association for non-payment of dues after thirty days' notice from the Secretary that such payment is due.

ARTICLE VI.

AMENDMENTS.

These articles may be amended by a majority vote of the Board of Managers, and subsquent approval by two thirds of the participating societies.

ARTICLE VII.

TIME OF GOING INTO EFFECT.

These articles shall go into effect whenever they shall have been ratified by three societies, and members of the Board of Managers appointed. The Board shall then proceed to organize, and the entrance fee of fifty cents per member shall then become payable.

RULES OF THE BOARD OF MANAGERS OF THE ASSOCIATION OF ENGINEERING SOCIETIES, ADOPTED MARCH 1, 1905, AND AMENDED AUGUST 18, 1906.

SOCIETIES.

Assessments.

1. Assessment bills shall be rendered to the societies quarterly after the mailing of the Journals for March, June, September and December.

2. Each society shall be assessed in proportion to the number of names upon its mailing list at the time when the assessment is made, provided that no society shall be assessed for less than twenty (20) copies of the Journal, and provided that no society shall be assessed for less than fifty (50) per centum of its membership at the time when the assessment is made.

3. Each society shall be entitled to receive, gratis, five copies of each issue of the Journal for each of its representatives on the Board of Managers of the Association.

Delinquent Societies.

4. Any society which shall remain indebted to the Association for a sum exceeding two dollars per member for more than ninety days after mailing of notice by the Secretary, shall be suspended from the privileges of the Association until the cause be removed, provided that this rule shall not apply to indebtedness on account of advertisements secured by the society for the Journal.

Government.

5. A meeting of the Board of Managers may be called by the Chairman at any time, and shall be called by the Chairman or Secretary upon the written request of any three members of the Board, and such call shall give not less than three weeks' notice of said meeting.

6. At any meeting of the Board of Managers, duly called as provided in Rule 5, one fourth of the whole number of members (including the Chairman) shall constitute a quorum, provided that not less than three of the constituent societies be represented at such meeting.

7. Motions for letter ballot shall be made and seconded and then forwarded by the Chairman to each member of the Board for discussion.

8. All letter ballots shall close four weeks after the date of mailing call, by the Chairman, for vote.

9. Rules of the Board of Managers may be amended at any time by a majority vote of the Board, as ascertained by letter ballot.

Officers.

10. The term of office of the Chairman and that of the Secretary shall be two (2) years, and shall begin on January 1 of the even years, but they shall remain in office till their successors are chosen.

11. The election of officers shall occur at any time at a called meeting of the Board, or by letter ballot between October 1 and December 1 of the odd years.

12. If the election is by letter ballot, the Chairman shall, through the Secretary, give notice of such election prior to October 10 of each odd year, and shall also give notice, at the same time, of the appointment of two tellers in one city, members but not officers of the Board to whom

the votes shall be mailed. These tellers shall open the ballots on November 1, and report the result to the Chairman of the Board. If no one has received a majority of the votes cast for either office, the Chairman shall order a new ballot, similar to the first, but limiting the names voted for to the two receiving the highest numbers of votes for that office on the first ballot. The tellers shall open the second ballot on December 1, and report as before. The Chairman shall then announce the result of the ballot to all the members, and the new officers shall act from the beginning of the following calendar year. In the event of the second ballot resulting in a tie, the Chairman shall select between the two candidates by lot.

13. Vacancies in the offices of the Board may be filled at any time, either by a meeting of the Board or by letter ballot. In case of a vacancy occurring, the remaining officer shall discharge the duties of both till the vacancy is duly filled.

14. The Secretary shall receive a salary of nine hundred dollars ($900) per annum.

ACCOUNTS.

Audit.

15. Prior to the close of each odd year, the Chairman shall appoint from the members of the Board of Managers, two auditors to examine and report upon the accounts of the Secretary.

JOURNAL.

Contents.

16. The matter published in the Journal shall be restricted to:

(A) Monthly.

1. Papers submitted by the societies for publication, including presidential addresses and memoirs of deceased members.
2. Proceedings of meetings of the societies.
3. Lists of officers of the societies.
4. List of members of Board of Managers.
5. Advertisements.

(B) Annually.

1. Annual report of Chairman and of Secretary of Board of Managers.
2. Articles of Association, Rules of Board and rulings of Chairman.

(C) Biennially.

Report of Auditors.

Conduct.

17. Arrangements with printers and illustrators shall be made by the Secretary, subject to the approval of the Board of Managers.

18. The arrangement of matter, the selection and manner of reproducing illustrations and all other matters relating to typography, shall be decided by the Secretary with the approval of the Chairman.

19. The Secretary shall insert in each issue of the Journal the following: Editors reprinting articles from this Journal are requested to credit the author, the Journal of the Association and the Society before which such articles were read.

20. Authors of papers appearing in the Journal shall have appended to their names only the words, "Member of................Society."

Reprints.

21. Reprints of papers appearing in the Journal shall be made, when requested for the account of the societies submitting the papers for publication.

22. Each author shall be entitled to receive gratis 50 reprints of his paper, with its discussion and illustrations, on condition that application for such reprints is made by the author, through the secretary of the society presenting the paper for publication, previous to the printing of the paper for the Journal.

23. The rates of charges to the societies for other reprints shall be adjusted by the Chairman and Secretary.

Illustrations.

24. Cuts, published with linear scales, shall bear metric scales, unless objection is made by the authors.

Advertisements.

25. The procuring and selection of advertisements, including the fixing of rate of commissions, shall be subject to the control of the Chairman and Secretary.

26. Advertisements procured for the Journal by the societies composing the Association shall be charged to those societies, less 90 per cent commission.

Subscriptions.

27. The rate of subscriptions to the Journal shall be $3.00 per annum.

28. Dealers shall be allowed on subscriptions a discount of 50 cents per annum.

29. Educational and charitable institutions may be furnished with the Journal at $1.50 per annum, subject to the approval of the Chairman and Secretary.

Exchanges.

30. Exchanges with other periodicals may be made subject to the approval of the Chairman and Secretary.

Sales and Gratis Copies.

31. The price of single copies of the Journal shall be 30 cents, less a discount of 5 cents to dealers.

32. Members of the societies belonging to the Association shall be entitled to receive copies of the Journal at 20 cents each. This rule is subject to amendment by the Chairman and Secretary in the case of scarce or surplus numbers, or of sets of back numbers.

33. The Secretary is authorized to furnish to the author of any paper to whom reprints are not given, and to each of those taking prominent part in the discussion, five gratis copies of the Journal containing such paper, and, at 15 cents each, additional copies of the issue of the Journal containing such paper, provided due notice be given in advance, stating the number of such extra copies wanted.

FINAL CONTROL BY BOARD.

34. The exercise of any discretions herein delegated to the Chairman and Secretary shall be subject to the final control of the Board of Managers.

ASSOCIATION OF ENGINEERING SOCIETIES.

Organized 1881.

VOL. XLIII. OCTOBER, 1909. NO. 4.

FILING AND INDEXING SYSTEM OF BOARD OF WATER SUPPLY OF THE CITY OF NEW YORK.

BY ALFRED D. FLINN, MEMBER BOSTON SOCIETY OF CIVIL ENGINEERS.

[Read before the Society, January 27, 1909.]

THE Secretary has requested me to put on record in the JOURNAL a description of the system of filing and indexing devised for the large and scattered engineer organization of the Board of Water Supply of the City of New York. In response, I have compiled a number of extracts from the regulations prepared under my immediate direction. These have been prefaced by an outline of the project and the organization so that the system may be intelligible.

To supplement the outgrown water supplies of the various boroughs of Greater New York, the Board of Water Supply was created by legislative enactment in June, 1905. This board has determined to develop successively four considerable watersheds in the Catskill Mountains and the ground waters of Suffolk County in eastern Long Island. From City Hall, New York, to the most distant proposed Catskill Mountain reservoir is 130 miles in an air line, and to the extremity of the Suffolk County system, 75 miles. Esopus watershed, the first to be developed, will have one impounding reservoir of 128 000 000 000 gal. capacity, sufficient to store also part of the waters of Schoharie Creek, to be brought in by a 10-mile tunnel through the mountain range. This reservoir, the Ashokan, is 90 miles from New York and 590 ft. above mean tide. From it, Catskill aqueduct, of 500-000 000 gal. safe average daily capacity, will convey the water to

Hill View reservoir, a 900 000 000 gal. equalizing reservoir at elevation 295, on the northerly boundary of the city. This aqueduct comprises several types of construction; Cut-and-cover, grade tunnel, pressure tunnel, reinforced concrete pipes, steel pipes lined with mortar and jacketed in concrete, and reinforced cut-and-cover under slight pressure. Its total length will be 92 miles, crossing the Hudson River, several broad valleys below gradient, and piercing several ranges of hills and mountains. When needed, branch aqueducts will bring the water from the Rondout and Catskill creeks. On the line of the Catskill aqueduct, 30 miles from New York, Kensico storage and distribution reservoir of 40 000 000 000 gal. capacity will be constructed. It will serve the double purpose of permitting repairs and inspection of the Catskill aqueduct between this place and Ashokan reservoir almost as well as a duplicate aqueduct, and of maintaining relatively near the city a reserve storage of about two months' supply.

At Kensico and Ashokan reservoirs there will be extensive aëration fountains, through which the water will pass when drawn into the aqueduct. At East View, 3 miles from Kensico reservoir, a large filter plant is to be built. Venturi meters, with 7 ft. 9 in. throats, are to be built into the Catskill aqueduct at three places, and current-meter gaging chambers will also be provided. Drainage shafts and unwatering equipments are to be adjuncts of the deep pressure tunnel siphons. From Hill View reservoir, a pressure tunnel deep in the rock will extend under the borough of the Bronx, Harlem River, Manhattan Island and East River to Brooklyn, whence large pipe lines will continue to Queens Borough and beneath the Narrows to Staten Island. At shafts along this tunnel connections will be made with the trunk mains of the distributing pipe system.

In Suffolk County the underground water is to be gotten by means of deep wells, probably of the California stovepipe variety. These wells will be spaced along a right of way 1 000 ft. wide, approximately parallel to the south shore of the island and about 2 to 3 miles back from the ocean. Branches will extend into several valleys. Small pumping outfits will raise the water from the wells into a 250 000 000-gal. concrete aqueduct, which will convey the water by gravity across Nassau County into the heart of Brooklyn. Here a large pumping station will elevate the water to the distributing level.

For the ultimate completion of these two projects the total cost may be roughly estimated at upwards of $200 000 000,

but this expenditure will be spread over many years, and the works will probably be completed by the following generation.

A little reflection will cause one to realize that a water-works project of such magnitude, with so diverse elements, will make more or less extensive demands upon nearly all branches of engineering and seek aid from several other professions. A great many arts and crafts will be laid under tribute. The complexity and volume of the materials to be filed and indexed now becomes apparent. Because of the geographical extent of the works, a large number of offices is needed during the years of construction. Further complication is caused by the size of the organization and the wide separation of its several units. Besides all this, the system must be devised and perfected as a minor detail, while the organization and works are being rapidly developed.

The Board of Water Supply of the City of New York consists of three commissioners appointed by the mayor. Its forces are divided into an Administration Bureau and an Engineering Bureau. The Administration Bureau is under the general supervision of the secretary, and at the head of the Engineering Bureau is the chief engineer. There are three regular consulting engineers and several experts who advise along special lines.

The Administration Bureau has charge of official records, accounts, payrolls, the purchase of equipment and supplies, and of general executive matters. Its work is divided among an auditor, a head bookkeeper, a chief clerk and a paymaster. All legal affairs come to this bureau, and, so far as necessary, are referred to the corporation counsel or to special counsel. Real estate transactions and the settlement of all claims relating to real and personal property acquired by the board, and all claims for damages not disposed of by appraisal commissions are handled by a special department of this bureau.

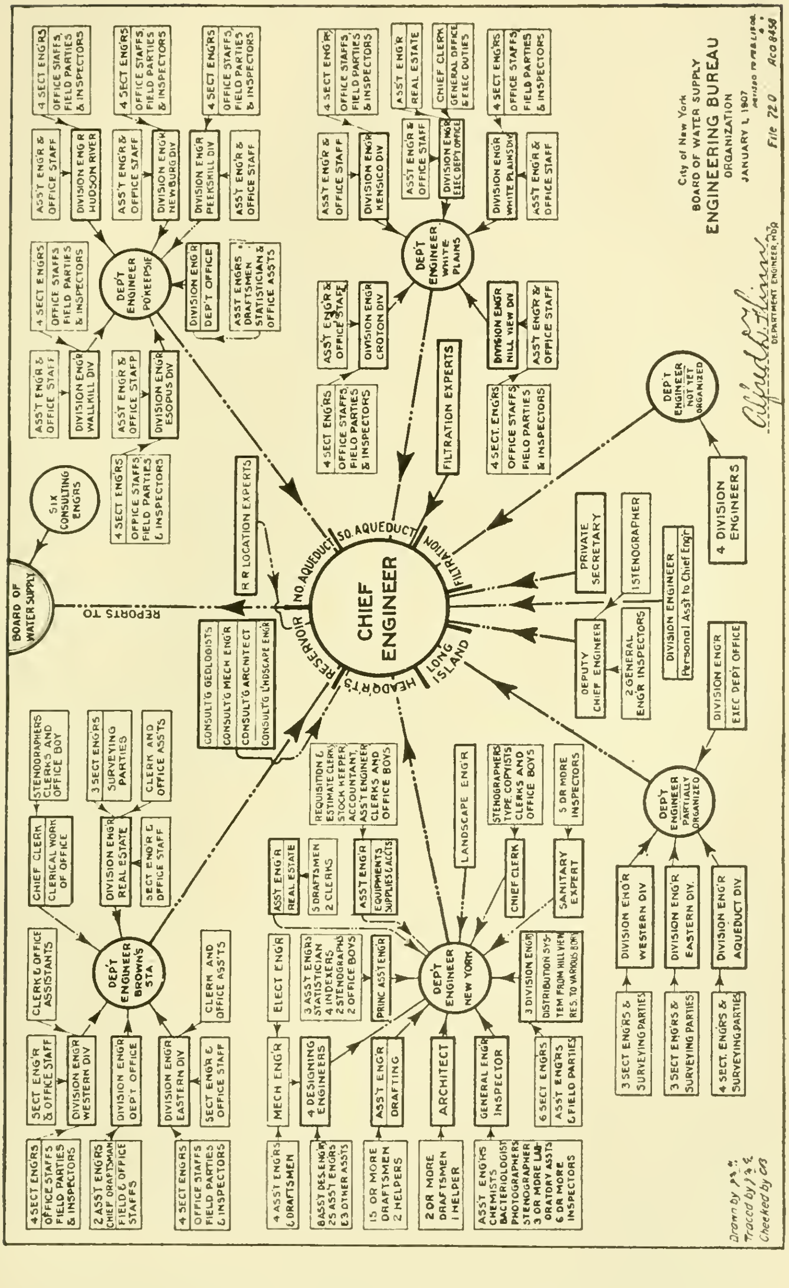
The Engineering Bureau is composed of six departments, determined by the character and location of different parts of the work, namely: Headquarters, Reservoir, Northern Aqueduct, Southern Aqueduct, Filtration, and Long Island. The departments are divided into divisions, and the divisions are subdivided into sections. This bureau has charge of all engineering matters, including surveys of all kinds, designs and specifications, superintendence of construction and inspection of materials. Communications from the Engineering Bureau to the Administration Bureau pass through the hands of the chief engineer, deputy chief engineer or the department engineer of

Headquarters Department. The organization of the Engineering Bureau is shown by the accompanying diagram, which has been modified as the work developed. It is probable that the filtration plant will be constructed by the Southern Aqueduct department, since the site is within the territory of that department and the preliminary surveys have been made by it. Instead of a filtration department, therefore, a City Aqueduct department may be organized to relieve Headquarters of part of the work connected with the delivery or distribution of the new water to the various boroughs of the city; the Distribution division of Headquarters department now has this work in hand and will, doubtless, be the nucleus of the new department organization.

The filing and indexing system described in this paper was not designed for universal application, nor even for general engineering use, but for the extensive and comprehensive system of water works for New York City being constructed by the Board of Water Supply. However, the principles and many of the details may be applicable in other large offices and even in small ones. The system is an appropriation and adaptation, to a large degree, and is the product of the combined efforts of many employees of the board. It is not perfect, but is proving satisfactory and is so flexible that it can be modified to meet varying needs or correct faults as discovered.

Better results could be attained if the men having the broadest and deepest knowledge of the works and organization could personally supervise filing and indexing. But these men are the chief engineer, heads of departments and divisions, and have much more important duties. Furthermore, filing and indexing must be done at least cost, and, consequently, by persons of less earning capacity. One of the most annoying difficulties in maintaining a large filing and indexing system is that those having sufficient ability to do the work will usually have other ambitions, soon outgrow such positions and move on. In large organizations with many high-salaried men, the economy secured by efficient and rapid handling of documents justifies somewhat higher remuneration for the man in charge than has commonly been paid. Furthermore, those in charge of filing and indexing should be given definite opportunities to keep familiar with the works and organization.

Memory is an indispensable adjunct to any filing and indexing system, no matter how complete. Nothing will more acceptably enhance the value of the service of the attendants. From the highest official down, the more accurately the few simple


City of New York
BOARD OF WATER SUPPLY
ENGINEERING BUREAU
ORGANIZATION
JANUARY 1, 1907
File 720
CHIEF ENGINEER
NO. AQUEDUCT
SO. AQUEDUCT
FILTRATION
LONG ISLAND
HEADQ'R'T'S
RESERVOIR
BOARD OF WATER SUPPLY
REPORTS TO
SIX CONSULTING ENG'RS
R R LOCATION EXPERTS
CONSULT'G GEOLOGISTS
CONSULT'G MECH ENG'R
CONSULT'G ARCHITECT
CONSULT'G L'NDSCAPE ENG'R
FILTRATION EXPERTS
PRIVATE SECRETARY
1 STENOGRAPHER
DIVISION ENGINEER
Personal Ass't to Chief Eng'r
DEPUTY CHIEF ENGINEER
2 GENERAL ENG'R INSPECTORS
4 DIVISION ENGINEERS
DIVISION ENG'R
EXEC DEP'T OFFICE
DEP'T ENGINEER POKEEPSIE
DEP'T ENGINEER WHITE PLAINS
DEP'T ENGINEER NOT YET ORGANIZED
DEP'T ENGINEER PARTIALLY ORGANIZED
DEP'T ENGINEER BROWN'S STA
DEP'T ENGINEER NEW YORK
DIVISION ENG'R HUDSON RIVER
DIVISION ENG'R NEWBURG DIV
DIVISION ENG'R PEEKSKILL DIV
DIVISION ENG'R WALLKILL DIV
DIVISION ENG'R ESOPUS DIV
DIVISION ENG'R DEP'T OFFICE
DIVISION ENG'R KENSICO DIV
DIVISION ENG'R EXEC DEP'T OFFICE
DIVISION ENG'R WHITE PLAINS DIV
DIVISION ENG'R CROTON DIV
DIVISION ENG'R HILL VIEW DIV
DIVISION ENG'R WESTERN DIV
DIVISION ENG'R EASTERN DIV
DIVISION ENG'R AQUEDUCT DIV
DIVISION ENG'R REAL ESTATE
ASS'T ENG'R & OFFICE STAFF
4 SECT ENG'RS
OFFICE STAFFS
FIELD PARTIES
& INSPECTORS
ASS'T ENG'RS
DRAFTSMEN
STATISTICIAN &
OFFICE ASS'TS
ASS'T ENG'R
REAL ESTATE
CHIEF CLERK
GENERAL OFFICE
& EXEC DUTIES
CHIEF CLERK
CLERICAL WORK OF OFFICE
STENOGRAPHERS CLERKS AND OFFICE BOY
3 SECT ENG'RS SURVEYING PARTIES
CLERK AND OFFICE ASS'TS
SECT ENG'R & OFFICE STAFF
CLERK & OFFICE ASSISTANTS
ASS'T ENG'R EQUIPMENTS SUPPLIES & ACCTS
5 DRAFTSMEN 2 CLERKS
REQUISITION & ESTIMATE CLERK, STOCK KEEPER, ACCOUNTANT, ASS'T ENGINEER CLERKS AND OFFICE BOYS
LANDSCAPE ENG'R
STENOGRAPHERS TYPE. COPYISTS CLERKS AND OFFICE BOYS
5 OR MORE INSPECTORS
SANITARY EXPERT
ELECT ENG'R
3 ASS'T ENG'RS STATISTICIAN 4 INDEXERS 2 STENOGRAPHS 2 OFFICE BOYS
PRINC ASS'T ENG'R
3 DIVISION ENG'RS
DISTRIBUTION SYSTEM FROM HILL VIEW RES. TO VARIOUS BOR'S
MECH ENG'R
4 DESIGNING ENGINEERS
ASS'T ENG'R DRAFTING
ARCHITECT
GENERAL ENG'R INSPECTOR
6 SECT ENG'RS
ASS'T ENG'RS
& FIELD PARTIES
4 ASS'T ENG'RS & DRAFTSMEN
8 ASS'T DES ENG'RS 25 ASS'T ENG'RS & 3 OTHER ASS'TS
15 OR MORE DRAFTSMEN 2 HELPERS
2 OR MORE DRAFTSMEN 1 HELPER
ASS'T ENG'RS CHEMISTS BACTERIOLOGIST PHOTOGRAPHERS STENOGRAPHER 3 OR MORE LABORATORY ASS'TS 6 OR MORE INSPECTORS
2 ASS'T ENG'RS CHIEF DRAFTSMAN FIELD & OFFICE STAFFS
3 SECT ENG'RS & SURVEYING PARTIES
4 SECT. ENG'RS & SURVEYING PARTIES
DEPARTMENT ENGINEER, HDR
Drawn by
Traced by
Checked by

requirements of the system are remembered and observed, and the more accurately the persons desiring documents from the files recollect and describe what is desired, the smoother will be the working of the system.

Filing and Indexing in General.

Filing is the systematic putting away of papers, drawings, photographs or books. An index is a means for pointing out where things are to be found; specifically it is a guide to a file.

It is to be desired that files be arranged so naturally and logically and be so well labeled that documents can be found with the minimum use of the index and the index be simple. Its simplicity should make the method readily comprehensible and enable one who enters the index by any one of several probable keys to find quickly and surely what he seeks.

The index should have plenty of helpful guide or partition cards. Colors can be used advantageously to distinguish different kinds of cards in one index. Drawers or trays containing the cards should be plainly labeled.

Cross-reference cards should be made for a sufficient number of words under which a person may look for any subject to insure his finding the desired paper, drawing, photograph or book; but it is frequently better to let a person try two or three times than to write an excessive number of cross-reference cards for synonymous words. Do not increase the bulk of the index by useless cards.

Everything to be filed or to be returned to the files must be put in receptacles provided for the purpose. *Only designated file keepers* are to be allowed to put anything into or return anything to any file. Otherwise things are sure to be misplaced. Anything taken from a file, bookcase or plan case must be accounted for at the time and must be returned as promptly as possible. Only authorized persons shall have access, directly or indirectly, to the official files.

Any system must work well or it will fall into disfavor and soon go to pieces.

When inquiry is made for a paper, and several in the filing group would answer the description, instead of taking time and causing the inquirer the annoyance of getting so minute a description as to distinguish the exact paper wanted, the file clerk should at once send the group of papers from which the inquirer can quickly select the one desired.

One important purpose of a filing and indexing system is to avoid the wasteful repetition of researches and computations of

more or less general character by preserving data once accumulated so as to be readily used again.

Filing and indexing are much simplified by preparing the materials to be filed with due regard to the system. Documents prepared within the organization should be thoroughly controlled in this respect. Documents received from outsiders can also be automatically molded to some degree by skill and forethought in preparing the system, especially documents from parties with whom continued relations are maintained, — contractors, for example. All indexing is based upon the subject list described below.

Preliminary, therefore, to directions for filing and indexing, are instructions to those who write letters and reports and make drawings, and who receive documents of all kinds. These instructions may be epitomized as follows:

Letter Writing.

Write concisely. Deal with one subject only in each letter. Do not write unnecessary letters. Date each letter. Write the subject in the place provided. Place initials of stenographer in upper left corner, also name of dictator if he is other than the party who is to sign the letter.

Standard Sizes.

Standard sizes for stationery, drawings, etc., have been established for universal use. Departure from standards may be made only by permission from Headquarters office, and for sufficient reason. Papers not of standard size should, if possible, be cut or folded to a standard size for filing; if too small, they may be mounted on standard sheets. Distinctive colors are used for stationery of the several departments, in harmony with the colors used for their indexing and filing.

Size.	Description.
3 in. by 5 in.	— Index cards, memoranda, reference lists on cards.
5 in. by 8 in.	— Field notes, record cards, printed specifications,* and many printed forms and pamphlets for field pocket use.
5 in. by 15 in., 22 in., and 29 in.,	allowing for punching for rings in note cover; and
8 in. by 10 in., 15 in., 20 in., 25 in.,	approximately, *to be folded to* 5 in. by 8 in., for diagrams, tables and drawings to be used in field note covers or otherwise with 5 in. by 8 in. papers.

* Type pages are same size for all contracts, including specifications; the 5 in. by 8 in. pamphlets have much narrower margins.

Size.	Description.
6 in. by 9 in.	Printed reports and other books or pamphlets.
$8\frac{1}{2}$ in. by 11 in.	Letters, computations, official photograph mounts, many printed forms, and most contract pamphlets.*
$8\frac{1}{2}$ in. by 14 in.	Traverse sheets, estimates for contract payments, expense accounts, leases and legal forms.
11 in. by $8\frac{1}{2}$ in., 13 in. and 18 in.	Sketches, diagrams, tables and small drawings to accompany computations, letters or reports. (The 13-in. and 18-in. sheets are folded to $8\frac{1}{2}$ in.)
14 in. by 17 in.	Payrolls. (Size prescribed by city comptroller.)
26 in. by 40 in, 20 in. by 29 in., $14\frac{1}{2}$ in. by 20 in.	Drawings of all kinds. It is intended that by far the greater number of contract and working drawings shall be 20 in. by 29 in. Real estate and topographical maps will be mostly 26 in. by 40 in.
19 in. by 24 in.	Green cross-section sheets to be used for estimates and other purposes.

Instructions to Stenographers.

Leave a margin an inch wide at the left side of all papers. This will permit binding or placing in note covers if desired. Use paper of standard size, $8\frac{1}{2}$ in. by 11 in.

The person dictating a letter must give the stenographer the subject (not necessarily taken from the subject list) to be placed at the head of the letter. The stenographer must see that this is done. The name of a person or place, or other explanatory words, may be written after a general subject to indicate to what person or place the letter refers and aid in cross-referencing. The original of each letter must be written in copying ink. For the reference files, carbon copies are to be made of all letters, reports, etc., which it is necessary to file in the office where they originate. All letters going out of any department office are to be copied (carbon) on green paper. Weekly reports, communications from the chief engineer to the board, and similar documents are to be copied (carbon) on white paper. Correspondence between offices in one building is not carbon copied.

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* Type pages are same size for all contracts, including specifications; the 5 in. by 8 in. pamphlets have much narrower margins.

In writing letters, both sides of the copy paper are to be used. After the first sheet of the letter has been written, using one side of the copy paper, this should be turned so that the second sheet of the letter can be copied on the other side. Subsequent sheets are to be copied in like manner. Space in the files is thus economized. This will apply only to green carbons.

In addition to the above reference copy, tissue copies of all letters and reports are to be made, preferably on a roller copier, such as manufactured by the Library Bureau or by Yawman & Erbe. Tissues of each day should be cut the following morning and preserved as a *continuous* roll, these rolls being kept in chronological order in suitable filing cases, plainly labeled. Tissues are not intended for ordinary reference, but as a safeguard.

Some letters are written in the New York office of the Engineering Bureau which require the signature of a commissioner or the secretary. Of such a letter a green copy should be made for the files of the Engineering Bureau besides the white copy for the board's files. After the letter has been signed, a tissue copy should be taken.

Handling Mail — General.

All official mail must be received, opened, stamped and distributed by the file clerk in all offices of sufficient size to need such services. Official mail includes all letters, reports, drawings, blue prints, books, catalogues and all packages and documents which originate in or are received at any board office, addressed to any employee of the board by his civil service or office title.

Each letter, after being opened, must be stamped by the file clerk with such dating stamp as may be provided.

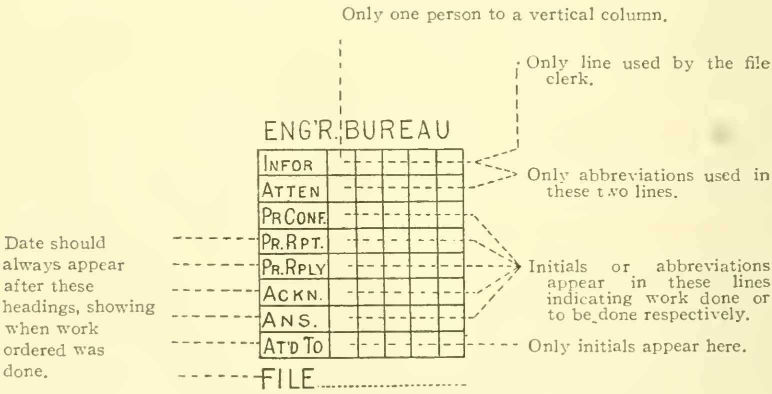
If a stamp of the appropriate kind is used, the number of the folder in which the letter is to be filed must be written after FILE NO., and in the first square after REF'D must be written the first two letters of the last name of the person to whom the letter is to be referred. When this person is through with it, he must put the initial of his last name in the square after AT'D TO, under the abbreviation of his name. In the second square after REF'D the first person may write the first two letters of the last name of any person to whom he wishes to refer the matter. The second person, after handling the letter, must put his last initial in the square after AT'D TO, under the abbreviation of his name. He can refer it to a third person and so on until the matter has been completely attended to.

When placing his initial in the space after AT'D TO and referring a letter to another person, one should be careful to indicate by pencil note on the margin what he has attended to or what remains to be attended to by the person to whom the letter is referred. If a person wishes a letter returned to him after having referred it to another, he should refrain from putting his initial in the square after AT'D TO and place a √ mark above the abbreviation of his name. The letter must then be returned to him before it is filed. When the last person who is to attend to the matter in the letter shall have finished with it, he shall sign or stamp all his initials after READY TO FILE. The letter should then be placed in a basket for filing.

Papers originating in the Engineering Bureau, or received by it, should not go to the commissioners until they have been examined by the chief engineer or by a properly authorized officer of the Engineering Bureau.

Handling Mail — Headquarters.

In Headquarters, the stamp shown below is used:



JAN 21 1909 9 48 AM

The Time Stamp.

Each letter after being opened shall be stamped on its face by the file clerk, as shown herewith, recorded, and then referred to the person concerned by placing the *abbreviation* of his name in the first vertical column of the time stamp opposite INFOR. *This is the only line of the time stamp to be used by the file clerk.*

With the relatively large mail handled in Headquarters office, it has been found convenient to assort the incoming mail

alphabetically each morning, according to the name of the author; in this order each letter is then given a serial number (leaving several numbers in reserve between A, B, C, etc., for the insertion of any mail which may arrive during the day). Beginning with No. 1 each day, they are then recorded in a loose-leaf binder, alongside the number corresponding to the one which has been placed on the letter, as indicated here.

MAIL RECEIVED................ ....19....

No.	AUTHOR	DATE OF LETTER	SUBJECT	REFERRED	FILED
1					
2					
ETC.					

In the column "Referred" should appear the abbreviation of the name of the person to whom the letter is referred (as shown by the time-stamp on the letter) and the date; if the same letter is returned to the file clerk to be referred to another, a record to that effect is made alongside the original entry in the loose-leaf binder. When a letter is returned to be filed, the file number which appears on the letter should be recorded in the column headed "Filed," alongside the original entry, so that the letter may be readily located in the file.

The Headings. — The headings may be used as written, thus expressing a request; or to indicate work already done.

Abbreviation. — The abbreviation of a person's name opposite any heading expresses a request to do the work indicated.

The Initial. — An initial indicates work done.

Check Mark. — Checked abbreviation opposite INFOR. or ATTEN. indicates to the file clerk that the person whose abbreviation is checked has seen the document, but wishes it returned to him. After PR. CONF., PR. RPT., it has the additional significance that the work expressed by the heading opposite which it appears has been done by the person whose initial or abbreviation is checked. The person is not through with the letter, however, so he does not put his initial after ATT'D TO, but instead checks his abbreviation. After PR. RPLY, ACKN., and ANS., the date accomplishes the same purpose. *Date must always appear after these headings.*

The Arrow. — An arrow shows from which person a request to do work comes.

The Date. — The stamp should show the chronology of a document with respect to PR. RPLY, ACKN., ANS. and FILE. The date placed in the next vertical column to the right of these

headings accomplishes this. *None of these steps should be omitted in using the time stamp.*

INFOR. = Information, and means paper, letter, report, sketch, etc., sent to a person for his information.

ATTEN. = Attention, and means that the person to whom the paper is referred shall attend to whatever is required by the paper or that part of it to which his attention is directed.

PR. CONF. = Prepare for conference, and means look up any data necessary and then confer with the person referring the paper.

PR. RPT. = Prepare report, and means prepare a report on the subject matter of the paper.

PR. RPLY. = Prepare reply, and means to prepare a reply for the signature of the person referring the letter.

ACKN. = Acknowledge, and means acknowledge receipt of the paper.

ANS. = Answer, and means answer the letter.

(The headings PR. CONF., PR. RPT., PR. RPLY., ACKN., ANS., may also have the significance Conference prepared for, Report prepared, Reply prepared, Acknowledged, Answered, — meaning that work has been done by a person of his own volition. This is indicated by the initial instead of the abbreviation.)

AT'D TO = Attended to, and means that the paper has been attended to in accordance with the reference above.

It is to be remembered that these successive references are recorded by the file clerk, and *under no circumstances should documents be passed directly from one individual to another.*

Not more than one person's name shall appear in any vertical column.

The paper will be referred in the order of the names in the columns.

In order to avoid confusion, the file clerk shall determine the abbreviation of each person's name to be used and notify all concerned.

When the last person who is to attend to a paper shall have finished with it, he shall sign or stamp all his initials and the date after FILE. The paper shall then be returned to the file-room clerk. *Only the last man to attend to a paper should sign after* FILE.

The file clerk must not file any papers until *all* the ATT'D TO columns under the abbreviations in the upper part of the stamp are initialed, and FILE filled in by the *last person* who has seen the document.

All letters and reports originating in Headquarters Department must be sent to the file rooms to be press copied. Letters having green carbons shall not be forwarded until the carbon has been received in the file room.

No one except members of the filing force is to be allowed in the file room. File clerks must enforce this rule.

Filing and Indexing Letters, Reports and Other Communications.

Letters, reports, etc., are filed in letter-size four-drawer unit vertical files. File units can be placed side by side to provide any number of drawers needed as the papers accumulate. In the drawers are folders of stout manila paper, each large enough to hold about fifty papers.

The index is on 3 in. by 5 in. cards, both white and colored cards being used to make convenient distinctions to expedite search. The cards are kept in single trays or in cabinets of two or more drawers, according to the size of the index. These also are on the unit plan.

An OUT card $8\frac{1}{2}$ in. by 11 in. is put in a folder whenever a letter is taken out, upon which is stated when the letter was taken out and to whom it was given. Guides or partition cards having metal tips containing labels or alphabetical or other tabs are used to subdivide the contents of a letter file drawer, to expedite the finding of a desired paper.

When a letter is kept out of the files over five days, a notice is sent to the person to whom the letter is charged, requesting him to return the letter with the notice or to renew it for five days more by marking "renew" on the notice. In any case, the notice is to be returned to the file room. This notice is repeated every five days until the letter is returned to the file room.

Special Files.

Most of the correspondence is filed in a general file with a general index. In Headquarters' office a few special files have been established and others may be added if found really necessary. A few similar special files may become advantageous in the field offices, but special files should be avoided, and with very few exceptions personal or individual files should not be allowed. Such files are likely to lead to confusion and so spoil a good system, besides causing unnecessary duplication of work and waste of stationery. Of course a man may withhold and properly care for communications of a semi-private or confiden-

tial nature which for obvious reasons should not be put in a general file.

The special files in Headquarters office are as follows:

1. Applications for employment.
2. Opinions of corporation counsel.
3. Communications of chief engineer to board.
4. Weekly and other routine reports.
5. Acceptances of appointments.

Applications for employment are filed alphabetically, according to the names of the applicants. For purposes of reference, applications are classified according to positions. These classes are indexed alphabetically, the name of each class being written on a guide card.

Opinions of corporation counsel are filed in chronological order and indexed in a special index under the subjects of which they treat.

Communications of the chief engineer to the board are numbered in chronological order and have a special index. Periodical routine reports are filed chronologically, each in its own series. Special indexes are made for them, as found necessary. Special reports are filed in the general file under the subjects of which they treat. Acceptances are filed alphabetically.

Contract Correspondence.

Correspondence concerning each of the formal numbered contracts is filed by itself according to the system described for the general file, using the same list of subjects so far as may be necessary. In these files each folder, besides having the regular subject number, has stamped conspicuously, CONTRACT NO. ——. Files of two or more contracts may be put into the same drawer and separated by suitable guides, each guide being plainly labeled with the number of its contract and the name of the contractor.

Filing and Indexing Drawings.

One employee in each office shall be held responsible for the proper filing of the drawings, and he alone should be allowed to put away drawings. In each office *all* drawings received from other offices should pass first through the hands of a designated

* ....Department.........................Division

Accession Number	TITLE	Description Note principal feature of drawing

employee, possessed of sufficient knowledge, who will see that each drawing is properly introduced into the system of filing and indexing or otherwise attended to.

Drawings are filed in plan cases provided for the purpose and indexed on 3 in. by 5 in. cards kept in convenient cabinets. Cases and drawers are numbered. Plan cases have been designed on the unit system.

Besides bearing a file number to show where it is filed, each drawing is given an accession number which distinguishes it from all other drawings and, consequently, is the convenient and certain designation for the drawing in computations, correspondence or conversation. Accession sheets contain complete description and record of every drawing made or acquired by an office of the Bureau for permanent filing. There is a double space across the accession sheet for each drawing.

Headings are shown below.*

An accession number is given to a drawing as soon as it is well started — at any rate as soon as any computations are made relating to it. The exact title and description can be filled out on the accession sheet when they are determined. The tracing of a drawing is given a different accession number. As near the lower left-hand corner of the tracing as possible, usually in the margin, is placed the word "REFERENCES" followed by the accession numbers, one or more, of the drawing or drawings from which the tracing has been made. For example, if a tracing is made from Acc. 2000, it will be endorsed "REFERENCES" Acc. 2000. If made from 2000, 3000 and 4000 it will be endorsed "REFERENCES" Acc. 2000, 3000 and 4000. The brown paper studies will be endorsed "TRACED AS ACC. ———." The same record must be made in the "REMARKS" column of the accession sheet. If a drawing is revised or changes or additions made in it, it should be given a new accession number and endorsed with the date of the revision. One should be endorsed "REVISED FROM ACC. ———" and its predecessor should be marked "SUPERSEDED BY ACC. ———." The same note should be made on the Accession sheet under "REMARKS" and on the cards of the index. Revised drawings and prints of any kind upon which additional work is drawn are accessioned like new drawings.

SECTION.................. DATE..........................19 NO.........

DATE	PURPOSE OF DRAWING	SCALE H-HORIZONTAL V-VERTICAL	KIND OF PAPER. SIZE IN INCHES	WHERE FILE Case | Drawer	INDEX UNDER	REMARKS

Generally, all drawings should be reaccessioned if lines are added or changes made on them, but drawings that show progress (progress diagrams), that is, drawings that are intended to be revised from time to time, should retain their original accession numbers and should be endorsed with the date of the latest change. The cross index cards should be similarly endorsed, and also the accession sheets. All previous editions of each drawing should be endorsed " REVISED TO " (the latest date).

Temporary accession sheets, properly numbered on the line for each drawing, will be kept in each drafting office, on which the draftsmen can make entries as needed. When a temporary sheet is filled, a new sheet properly numbered in advance is substituted. The filled sheet is promptly checked and corrected, and then sent to Headquarters or some other office having a large flat-platen typewriter, where it is neatly copied in triplicate. One copy, with the original, is returned, the second sent to the appropriate department office and the third retained at Headquarters. These copies are kept in suitable loose-leaf covers. After filing the final accession sheets and copies, the temporary sheets are destroyed.

In Headquarters department when a study, a map or a similar original drawing is to be accessioned, the designer or plotter takes it to the plan clerk and fills out the accession sheet so far as possible; the file clerk puts on the proper file number. " DESCRIPTION " should be filled out sufficiently for the drawing to be readily recognized when called for. Under " TITLE," if the title is not determined, shall be written in pencil the name of the individual to whom the drawing is charged. If the title is determined, it shall be entered and the name of the individual placed under " REMARKS." An employee shall keep track of all drawings thus charged to him. Likewise, draftsmen shall go to the plan clerk for file and accession numbers for tracings.

Under no circumstances shall a file or accession number be changed except by the plan clerk, who shall make corresponding changes on the accession sheets and the index cards. Every drawing, wherever found in an office, should show by its numbers or other endorsements that it has become a part of the system. Any drawings lacking the plan clerk's marks should be followed up to see why they have not been introduced into the system.

Contract drawings, besides accession and file numbers, are numbered consecutively in each contract set, as follows: " Contract No. 12, Sheet 20, Sheets in set, 45." For general use, contract drawings are lithographed to 11 in. in height, folded as

necessary, and bound in pamphlets 8½ by 11 in., like the contract. Such lithographs, of course, bear the same designating numbers as the tracings from which they are made. Similarly, "working" drawings are photographed to about 7½ by 11 in. and blue-printed for convenience and economy on sheets 11 by 14 in., thus avoiding the use of larger sheets in the field.

Blue prints and black prints may be given out by the plan clerk when authorized and no record need be kept, unless a print is stamped on its face "File Copy." In using prints for studies, employees should be especially careful to see that when lines are added or other changes made, they are reaccessioned like new drawings, if they are to be kept. The plan clerk, when receiving drawings, should observe file and accession numbers to see that the rules have been followed and to find out whether other copies of the same drawing have previously been received and are on file.

Drawings charged to individuals will be called for at the end of a month,* memoranda being sent by the plan clerk to each such individual weekly for drawings falling due during that week. Drawings may be renewed at the end of the month, if necessary. Individuals will be held strictly responsible for drawings charged to them and must afford the plan clerk every facility for locating them at any time. Drawings should not be passed from one individual to another in Headquarters office without going through the plan clerk's hands to have proper changes made on the records. It will aid in keeping track of a drawing, while outside the files, to attach a slip of paper reading: "Charged to Mr. ———. Do not remove or borrow."

Detail "working drawings" required under contracts for construction purposes are signed by the chief engineer. Such drawings must be prepared sufficiently in advance of the time when they will be needed to avoid delay to the field engineers and the contractor. If additional information is needed and is not received from the field early enough to allow ample time for the preparation of the drawing, the designing engineer responsible should send a request for the information, stating the time when it will be needed.

Working drawings are marked with the number of the contract in the same manner as the contract drawings. Most working drawings will be explanatory of some contract sheet. Each such working drawing is to be marked with the number of the sheet which it modifies with a letter to indicate its place in

* Would better be fortnight.

the order of progress, as follows: The first working drawing made to explain Sheet 26, Contract 12, is marked, "Contract 12. Sheet 26A. Working Drawing." Later working drawings explaining the same contract sheet shall be marked "26B," "26C," and so on.

Working drawings containing standard details applicable under several contracts will be marked in the upper right-hand corner "Working drawing," without a contract number, and will be designated by their accession numbers. If, under any contract, working drawings become necessary which cannot be considered the modification or explanation of one of the contract drawings, such sheets will be designated by their accession number only, but should contain, in the upper right-hand corner: "Contract No. ———. Working drawing ———."

If changes should become necessary on any signed tracing, especially a tracing which is to be lithographed, the assistant engineer in charge of the drafting room or the designing engineer (including architect, mechanical engineer and landscape engineer) who first gives orders for such change shall put a large blue-pencil cross over the department engineer's signature or the other signature which makes the tracing finally authoritative, thus indicating that it is to be changed. Such cross shall not be removed until the changes have been completed, checked by the designing engineer, and accepted by the party whose signature is crossed. Changes on important tracings which have been signed should be made only for weighty reasons. All errors which can be discovered by checking must be eliminated before the final signature is obtained.

The accession number is put in ink on each drawing in its lower right corner. The entry is made on the accession sheet as directed below.

Under TITLE, write the title of the drawing in full, excepting the two lines which appear on all drawings made in Board offices: City of New York, Board of Water Supply.

Under DESCRIPTION, write, briefly, enough about the drawing to tell what it shows. Do not repeat what is in the title, but supplement it. Abbreviations which can be readily interpreted may be used here.

In the column headed PURPOSE OF DRAWING, use the following abbreviations:

L Land plan, or map.
P Preliminary drawing or study.
C Contract drawing.
W Working drawing.

E Estimate cross-section, progress diagram or similar drawing.
R Record drawing (of completed construction work).
Z Foreign drawing used for reference.

Under KIND OF PAPER AND SIZE IN INCHES, use the following abbreviations on the upper line, and on the lower line write the outside dimensions of the drawing:

W	White paper.
B	Brown paper.
T	Tracing cloth.
T P	Tracing paper.
W P	White print.
G P	Gray or green print.
B P	Blue print.
Black	Black print.
Lith	Lithograph.
Cr-Sec	Cross-section, paper or cloth.
T Cr-Sec	Tracing cross-section, paper or cloth.
Pro	Profile paper.
T Pro	Tracing profile paper.
Neg	Vandyke negative.
M	Mounted on cloth (to be written after other designation).

The column headed WHERE FILE should be filled *in pencil* with file number as soon as the drawing can be given a place in one of the plan cases. If the drawing should ever be put into another plan case, the numbers on the accession sheet should be changed at once, also the corresponding numbers on the drawing and on all index cards.

In the column headed INDEX UNDER shall be written a word, to be put on the index card, under which a person would naturally or properly look when searching for the drawing.

The different departments are designated by letters in filing, indexing and accessioning drawings, and have distinguishing colors for index cards. Foreign drawings, meaning those originating outside of this Board's jurisdiction, are designated by an X.

Divisions use their department colors and are designated by an additional initial. For example:

Northern Aqueduct department, **N**
Esopus Division of ditto, **NE**

Each field department office and division will accession all its drawings independently, each having a series of numbers beginning at 1 and using its department and division letter. In Headquarters, only one series will be used, the numbers being assigned by the Drafting division. Thus: 491, S 5440 and R 721 indicate drawings originated in the Headquarters, Southern Aqueduct and Reservoir department offices respectively, and NE 299 is the accession number of a drawing originated in

one of the offices of the Esopus division of the Northern Aqueduct department. Division offices will supply section offices with accession numbers by sending temporary accession sheets properly numbered in advance. Section office drawings will be accessioned as though they originated at division offices; that is, a section office will not have an independent series of numbers, but will use blocks of numbers in the division series.

Two indexes are provided for drawings in Headquarters office. First, an index by accession numbers on Form 256 E, with Form 270 E printed on the back, the cards being arranged by accession numbers; and, second, an alphabetical index in which the cards are written under local terms, elemental topics, a predominant feature of the drawing or the most likely subject by which the drawing wlll be asked for. Several cards may be in the second index for the same drawing. The main card will be of the color of the department in which the drawing originates or is received from a source outside the Board's offices, and the cross reference cards are white. All cross references should be noted on the main card, so that all cards may be readily located in the index. The following form is used for this index:

A TO Z INDEX

TITLE

	ACC.
DATE	SIZE
PURPOSE	FILE
SCALE	KIND

All drawings in each department and division office shall be indexed on SUBJECT cards, the distinguishing color of the department where the drawing originated being used. All of these cards are kept in the same index. The guide cards are buff colored.

Cross-references are made in sufficient number to insure the finding of the drawing, plain white cards being used. Index cards are typewritten so far as practicable.

Drawings or copies of drawings from other board offices, if filed in the office where received, are indexed on RECEIVED cards of the color of the department from which they come, these cards being kept as a separate index. In the Headquarters accession sheet of the department from which they come, note under REMARKS as follows: Hqs. Copy Case......Dr......

Should any drawing be sent to another office for permanent or temporary filing, or taken from its files for any other purpose for any considerable length of time, a proper note should be made on the back of its index card. Receipt should be taken for any drawing leaving its file.

Division engineers may, if they see fit, devise methods of indexing their section office drawings so as to distinguish them from those originating in division offices.

If any drawing which has been given an accession number be destroyed or sent *permanently* from the office in which it was filed, a note of the facts shall be made in REMARKS column opposite the correct number on the final accession sheet.

Filing and Indexing Photographs.

Photographs (negatives) are to be of uniform sizes, 6½ in. by 8½ in. for outdoor work and 7 in. by 10 in. for copying drawings. For special work suitable sizes may be permitted. Finished photographs for the official file at Headquarters office are to be printed on 8½ in. by 11 in. heavy unmounted Velox, platinum or other paper giving a permanent black or gray picture on white ground. Photographs for department files may be like those for Headquarters, or blue prints.

Each department and each division is to number the negatives taken by its own photographer in a series of its own, beginning at 1 and using the department abbreviation and division initial, and to keep an index of photographs by numbers with the necessary cross-references. Negatives taken by the official photographer are to be numbered in another series, using the abbreviation Hdq., with the initial of the department in which the photograph was taken. Each negative is marked in the lower right-hand corner with the date and accession number. Negatives are stored in Headquarters office.

Official files of photographs in Headquarters and field department offices are kept in standard 8½ in. by 11 in. letter file drawers. Files are divided, so as to keep photographs of real estate, construction progress photographs, and photographs for accident and damage cases separate. Each class should be subdivided by metal-tip guide cards, according to locality or subject. In each subdivision the pictures should be arranged in chronological order. An OUT card should be used if a photograph is taken from the file.

Filing and Indexing Catalogues and Circulars.

Catalogues and circulars are numbered and filed according to size:

Up to 7 by 9 in.	1 to 1 000
7 by 9 in. to 9 by $11\frac{1}{2}$ in.	1 001 to 2 000
Larger than 9 by $11\frac{1}{2}$ in.	2 001 to 3 000

If needed, additional blocks of numbers will be assigned.

Catalogues are alphabetically indexed on 3 by 5 in. cards, under firm names and subjects.

Computations.

For survey computations, such as stadia notes and traverse tables, and for estimates for payments under contracts, special sheets are provided. Each assistant engaged upon general computations is furnished with an *individual* computation cover holding standard punched computation sheets, $8\frac{1}{2}$ in. by 11 in. size, with printed blank heading, thus:

Subject...File No.......... ....
....Acc. No....................
....Sheet....Tot. in Comp......
Computer................ ....Checked by...................Date..................19....
Made in Connection with

All general computations must be made in *ink* on these sheets, using one side only, except as otherwise directed by a department or division engineer. This makes it possible to get a print of any sheet, if needed, and thus save copying. The margin on the left of each sheet must be kept blank.

In the Distribution division the standard filing system of the engineering bureau is supplemented by dividing field notes according to coördinates. A key-map covering all the ground of the distribution division (Greater New York) has been prepared and coördinates plotted on it to the nearest 20 000 ft., the center of each square being marked by a dot. Smaller maps are prepared of each 10 000 ft. sq. on a scale of 1 in. = 2 000 ft. The north coördinates run into hundreds of thousands, while the east do not exceed tens of thousands. Whole figures are used to designate points to the nearest thousand feet by making the two figures to the left of the decimal point represent the east coördinate to the nearest thousand feet, while the figures farther to the left represent the north coördinate to the nearest thousand feet. For location to the nearest hundred feet, the first figure to the right of the decimal point represents the north coördinate, while the second represents the east: Thus, 15 426.63 = 154 600 N and 26 300 E; 15 426 = 154 000 N and 26 000 E. This could be extended to locate points to the nearest foot, if necessary, by increasing the number of decimal places. Notes

numbered in this manner are filed numerically. Surveying notes should ordinarily be located to the nearest thousand feet, and construction notes to the nearest hundred.

SUBJECT LIST.

A subject list is a scheme of classification of the data collected, and is, consequently, the basis of indexing. To conceive and properly arrange a list of subjects with a suitable method of numbering was the difficult task. Two or three attempts were made before the list in use was adopted. Its numbers and letters, which are the symbols for the subjects, furnish a system of brief and specific designations by which references can be conveniently made, especially in computations.

Assistant engineers in charge of computations should, therefore, be thoroughly familiar with the index so that they may choose their titles and arrange their computations in such a way on successive sheets that they can be readily filed by the index as it exists. It frequently happens that individual computers do not see much beyond the work that they are engaged upon, so that they are incompetent to write a proper title or fill out the heading, "Made in connection with." Likewise those in charge of filing and indexing letters, reports, drawings, etc., need to know the subject list very thoroughly.

The index is not intended to be adequate for *all* the detail that arises in some instances, and a liberal use of tab cards for further segregation is contemplated beyond its scope. The assistant engineer at headquarters, in general charge of filing and indexing, should recognize local needs and not endeavor to construe the index for cases where it obviously does not apply or where a local method of filing and indexing "beyond the scope of the index" would better meet the requirements. For example, L 3.0A is the file number for real estate data of Ashokan Reservoir, but the file is more readily further subdivided by parcel and claimant numbers than by any of the subdivisions of reservoir given in this index.

The SUBJECT LIST embraces two parts, and the index correspondingly divided.

First, the list of *MAIN STRUCTURES* to be built by the board.

Second, the *GENERAL SUBJECT LIST* (a list of materials and methods, bibliography of structures similar to the "main structures," etc.).

For ease in consulting, the index is arranged as follows:

Under each of the "Main Structures" the subdivisions are arranged alphabetically (A to Z) and numerically by file numbers, beginning with 1 (1 to n).* The "General List" is arranged alphabetically (A to Z) and numerically beginning with 1 (1 to n). The same subjects appear in both the numeric index and the alphabetic, with the same file numbers, with the exception that cross-references are given in the alphabetic index while none appear in the numeric index, so that the distinction is one of arrangement and function, the alphabetic index enabling a person unfamiliar with the system to locate matter in the files, while the numeric index would be used by the initiated.

In the alphabetic index the subdivisions of each of the main structures are arranged alphabetically and the general list is arranged alphabetically throughout.

In the numeric index each subject is given an integral number and its subdivisions are given a decimal as in the Dewey system. The first eleven subjects are structures which will probably be built by the board. Some of these subjects, as *watersheds*, *reservoirs*, *aqueducts*, *filters*, *distributing conduits*, follow each other in the logical succession of their utility, while others, for example, *aëration works*, *water-power development*, *pumping and power stations*, are more or less collateral in their relation to the former. Each of these subjects is fully subdivided, while the rest of the list (i. e., the General List) may be added to or developed as necessary. For works of a different class, naturally, the subject list and index would be differently arranged; some topics which are now made principal headings would become minor, and some of the minor items would become the principal headings, as, for example, in a water-power development or railroad project.

The principle of the subdivisions of the main structures is perhaps most easily understood on the basis of cost. In estimating the cost of a structure, everything which its construction occasions is charged against it; similarly, everything likely to arise in the construction of any particular structure has a place in the index under some subdivisions of the integral number representing the structure. Under *reservoirs*, for example, the main subdivisions are, *improvement of site*, *dams and dikes*, *conduits and piping*, *gate-houses*, *highway construction*, *railroad construction*, *lighting and telephone* and *special structures*, all likely

* n is used, as commonly in algebraic formulas, to mean an indefinite number which cannot conveniently be stated precisely but which is readily determined by given conditions in a specific case.

to enter into the construction and design of a reservoir. The same is true of aqueducts and of all the other main structures. It is apparent, therefore, that some subjects, such as *railroad relocation*, may have several file numbers, selections of file number in any instance depending upon which structure the work was "done in connection with."

The "MAIN STRUCTURES" referred to are as follows:

1.0 General Schemes of Water Supply. (Summaries, etc., involving more than one of the main structures.)
2.0 *Watershed.* Rainfall. Stream Flow.
3.0 *Reservoir.* Dams and Dikes. River Control. Gate-houses.
4.0 *Infiltration Galleries and Wells.* (Not borings for Geologic investigation.) California Stovepipe Wells.
5.0 *Aqueducts.* Cut and Cover. Grade Tunnel.
Siphons. Steel Pipe. Pressure Tunnel. Reinforced Concrete Pipe. Iron Pipe.
6.0 Filters (Slow Sand).
7.0 Mechanical Filters.
8.0 Distributing Conduits. (Street mains, not main pipes to Brooklyn or Richmond, for which see AQUEDUCTS.)
9.0 Aëration Works.
10.0 Water-Power Development. (Not power plant or machinery, for which see 11.0.)
11.0 Plants, general (power, pumping, contractor's plant, etc.; miscellaneous machinery).
59.0 Civil Service.
72.0 Organization.

Intermediate numbers have been left so that new subjects may be added more nearly in their logical sequence.

The rest of the index, known as the general index or the "GENERAL SUBJECT LIST," is made up, as has been stated, of a list of subjects pertaining to engineering methods, articles, materials, etc., investigations on which are general and should, for the purpose of reference, be so indexed, though they may have been "made in connection with" some special structure.

Difficulty may arise in some cases, however, in differentiating between matter which should be indexed under some special structure or under a heading of the general list, and each paper should be carefully scrutinized before indexing to determine its bearing on the work. This difficulty may be minimized, however, at the time papers originate, by remembering that the subject list is the mold into which they must be cast. Even with great care in indexing, data of general import will find their way into the files of some special structure for reasons of expediency or the personal equation of the indexer, so that a person consulting the general reference file should bear in mind that he may find data on his subject in the file of a special structure.

Treatment and Locality Letters.

In addition to the file number, treatment letters are used before the file number indicating the point of view from which the subject is considered, and after the file number a locality letter is used to distinguish between structures of the same kind but occurring in different places. For example, the file number of *aqueducts, general*, is 5.0, while D 5.0 is a general problem of aqueduct design, the treatment letter D representing design; D 5.0 C is a general problem of design for the Catskill *aqueduct*, the C representing Catskill aqueduct. P 5.3 CG is a preliminary estimate of cost of the Garrison tunnel of the Catskill aqueduct, P being preliminary estimate; 5, aqueduct; .3, grade tunnel; C, Catskill aqueduct; and G, Garrison tunnel. B 5.0 W is general information on the Wachusett aqueduct, B standing for outside information and W, the locality letter for Wachusett aqueduct.

Treatment Letters for Field and Office Work, to be used before File Numbers, in Filing Correspondence, Field Notes, Plans, Computations, etc.

Capital and small letters are given for the same definition. The small letters are used on notes, etc., made in the field, while the capitals are for office use, in order to show without further explanation in referencing whether a field or office note or computation is referred to. In the case of plans and correspondence, which are always office products (plane table work and sketches excepted), capital letters are uniformly used, and not the small letters.

Where note appears with any treatment letter stating that it may or may not be used with any of the classes of data to be filed, namely, plans, computations, correspondence, etc., the notes are provisional in so far as no cases have arisen that would make their use apparent. When any such cases do arise, attention of Headquarters should be called to them, so that the change may be made uniform for all offices.

"Correspondence" is used here broadly to indicate any matter, letters, reports, etc., that are filed in the vertical 8½ in. by 11 in. file.

The word "foreign" is used in reference to works not under the jurisdiction of the board.

Definitions of Treatment Letters.

F. Field Work. Trigonometric and other *office computations based on field notes* for use in laying out work or making

field work available for subsequent use in either the office or field study or design or construction. Subdivide by field treatment letters if desired. Data taken from the field notes should be referenced on office computation sheets by file number, with the small letter showing the nature of the field note prefixed, as: l 5.0 C is a reference on an office computation to a field note of a landtaking survey on the Catskill aqueduct. The computation sheet on which this reference appears would have the file number Fl 5.0 C.

As a general thing, office computations will be on $8\frac{1}{2}$ in. by 11 in. sheets and field notes on 5 in. by 8 in. sheets. The small letters, therefore, will appear before file numbers on 5 in. by 8 in. sheets and the capitals before file numbers on $8\frac{1}{2}$ in. by 11 in. sheets.

Fl 5.0 C. Office work or computations on landtaking survey notes on aqueduct.

F △ 3.0 A. Office work or computations on Ashokan Reservoir triangulation field notes.

D. Studies and Designs. Including computations of ideal quantities and costs per foot; also including *estimates of cost for use in comparing alternative schemes*, or comparing alternative types of construction, locations or designs of a structure. May be used for filing plans, computations and in correspondence file for reports and letters. Brown paper or other plans that constitute studies or designs will have this letter prefixed to the subject file number. This will serve to separate the study drawings from topographic plans of the same structure, the latter having the prefix Z before the file number.

When topographic plans have lines drawn on them showing the probable location of an aqueduct, dam or other structure, they then become studies of location and should have the treatment letter D before the file number. Such drawings as a rule should be reaccessioned, as the added lines have altered the drawings from their original descriptions on the accession sheets. The original topographic plans which show a broad strip of country in the general vicinity of the above-mentioned location will have the prefix Z before the file number.

Contract drawings will be filed by contract and may have either Z or D prefixed if desired. Cont. No. 2, 5.2 C, is the file number of plans for cut-and-cover sections of the Catskill aqueduct, Contract No. 2.

Plans of a general nature that could be used for subsequent contracts, but were " made in connection with " some particular

contract, should be filed in a "Contract, General," or "All Contracts" file and cross-referenced under the specific contract which they were "made in connection with."

P. Preliminary Estimates. Calculations made on a scheme, structure or section of work for which the type of construction is already determined or assumed, for the purpose of finding its probable cost *for financial purposes*, not for comparing designs. (The engineer's formal estimate, which is computed by items just as they appear in the contract, is put below. See *E*.)

P may be conveniently used in some cases for estimates of time as well as cost, as, for example, in the correspondence file a report on the probable time and sequence of letting contracts or an estimate of the time of completion of the Garrison tunnel. P may be used for computations or correspondence. The phrase "for financial purposes" constitutes the difference between P and D. Data for a comptroller's estimate, for example, should have P.

p. Measurements for Estimate for Partial Payment.

E. Contract Estimates. Includes the formal, preliminary, engineer's estimate, and all estimates for payment. Not used ordinarily for plans or correspondence.

L. Land Takings and Damages, Real Estate, etc. Used for plans, computations and correspondence on the main structures to be built by the board.

l. Land Taking Surveys.

T and t. Tests and Inspection. Also experiments. T used for plans, computations, correspondence, laboratory work, tests, experiments and laboratory records. Statistics or records of foreign work have the prefix B in preference to T, or, if it appears desirable, B may be subdivided by T, as BT 18.33, a foreign compressive test on cement; but in filing the B should be given the precedence, that is, filed by B first and then under T or other treatment letter.

G and g. Geology and Underground Investigations. Includes borings and test pits, etc. G may be used for plans, computations, correspondence, etc.

K and k. Cost, by Force Accounts, on Board of Water Supply Work. Cost on other works, see B. Not ordinarily used for plans or correspondence. Use k for field data.

S. Specifications. Used before file number of materials or structures, not before 72.12 or 72.15. Not ordinarily used for plans or correspondence.

B. Bibliography. Includes all information in regard to

"foreign" works gathered by members of the Board of Water Supply force or outside data made by outside people. Used for computations, correspondence, drawings. This letter is applied to foreign data only, and it takes precedence in the order of filing over any of the other letters, the use of which might be indicated in any particular case. For example, a record of borings on the Pennsylvania tunnels could have the file number G 71.0 (71.0 = Tunnels, General), according to the definition of G; but it is better to use B in order to separate foreign boring data from that originating in the Board's offices; and 70.0 (70.0 = Borings, General) instead of 71.0, as the data collected were for general information on borings regardless of their relation to tunnels. If sufficient information is collected on any of the subjects, it might be advisable to subdivide B by the other letters, as BG, foreign geologic information, etc. Always file by B first, however.

△. *Triangulation.* May be used for plans if desired. Not ordinarily used in correspondence file.

Z and z. Topography. Topographic surveys for any structure. Use Z on topographic plans. See definition of D.

bl. Bench Levels.

y. Line and Grade for Construction.

R and r. Record Measurement. On completed work, including measurement for final estimate.

R may be used for record plans; Fr for record computations, etc.

The LOCALITY LETTERS may be chosen as necessity demands by those locally concerned, but they should not be used before notifying Headquarters, in order that duplications may be avoided. An index of these abbreviations should be kept in each office and additions will be sent from Headquarters, where a general index of all abbreviations will be kept. Headquarters should, therefore, be notified at once of the desire to use an abbreviation or locality letter after the file number where one does not already exist.

The same course should be followed in the establishing of new subjects or the classifying of subjects under the general heads given. These should be sent to Headquarters with the suggestion of the proper filing place; a decision will then be made and transmitted to all the offices. A card index to these decisions will be kept at Headquarters to insure filing similar data always in the same place.

By the use of these treatment and locality letters it is possi-

ble to separate data of a given kind on any structure or part thereof from all other information of the same character or similar information about other structures of the same kind.

In certain cases doubt may arise as to the proper file number to select for a particular topic. For example, referring to the general list and the TREATMENT LETTERS:

G = Borings and underground investigations.
70.0 = Borings, general.
Ag. 23 = Borings on aqueduct line under Agreement No. 23.
G 5.0 C = Borings on Catskill aqueduct.
72.15 = Agreements.
70.2 = Boring apparatus.
B 11.0 = Contractor's plant.

The question might readily arise as to where these numbers should be used, and undoubtedly there would be border-line cases where no two individuals would index the same, but in general as follows:

Index general information on borings under 70.0, using B 70.0 for outside data. Index general information on boring rigs under 70.2, using B 70.2 when contractor's plant. (If the work was done by the board, it would not be filed in an agreement folder or with the letter B, but in the general file, using the subject-list topics for subdivision.)

Index general information about *agreements*, *specifications for agreements*, *requests for bids*, etc., under 72.15.

Use B 11.0 for a large plant as in agreement 37, but file the boring rigs under B 70.2.

It should be observed that the General Subject List contains the "MAIN STRUCTURES" and some of their subdivisions with the same file numbers that they have when considered as "MAIN STRUCTURES" and subdivisions thereof, the distinction arising in the use of the locality letter after the file number. For example:

Reservoir, GENERAL SUBJECT LIST — 3.0 or B 3.0 Cr. [B, foreign data; Cr., Croton].

Reservoir as MAIN STRUCTURE to be built — 3.0 A [A, Ashokan Res.].

The letters before and after the file number could be used similarly for any of the subdivisions of reservoirs. For example:

Dams, GENERAL SUBJECT LIST — 3.4 or B 3.4 Cr.

Dams Sub. of the MAIN STRUCTURE — 3.4 AO [Ashokan Reservoir, Olive Bridge Dam].

In some cases where a subject appears under each of the main structures a different file number is given to it in the gen-

eral list. For example, excavation appears many times in the index under each of the main structures, so that *excavation, general*, is given a distinctive file number in the general list. On the contrary, the only place where dams occur is as a subdivision of *reservoir*, and consequently the same file number is used for dams in the general list.

Before making additions to the general list these cases should be borne in mind so that unnecessary duplication of file numbers for the same topic may be avoided. Wherever a topic has several file numbers already under the main structures, it is better to establish a new one in the general list rather than arbitrarily to select one of the many for the general index, trusting to the locality letters to accomplish the desired separation of general from specific data.

Reference to the numeric index will show that in some instances illogical arrangements have been permitted in order to avoid duplication of the file numbers for the same topic, and the consequent uncertainty and doubt in indexing and locating matter in the files. For example: ACCIDENTS 72.34 appears as a subdivision of employees under Organization, and all data about PERSONAL ACCIDENTS, whether to employees or not, is filed here rather than establish another number for "ACCIDENTS" in general list. Similarly, *steel pipe* appears as a subdivision of siphons with the file number 5.42, and all general information on *steel pipe* is filed here, whether about siphon or not.

As an example to illustrate the system, one of the decimal divisions of the numeric index is here reproduced, viz., the decimal class .4, embracing the subject of Dams, under the unit 3, RESERVOIRS, as numbered among the MAIN STRUCTURES. It extends from 3.4 to 3.465:

3.4 Dams and dikes, to be known by letters, Board of Water Supply dams to be filed under their respective reservoirs; foreign dams, even when important enough to be represented by a letter, to be filed under reservoirs and dams in general. Method shown in following list:

3.4AO Olive Bridge Dam of Ashokan Reservoir.
3.4AT Tongore Dam ,, ,, ,,
3.4AA Ashton Dam ,, ,, ,,
3.4AB Brown's Station Dike of Ashokan Reservoir.
3.4KV Valhalla Dam of Kensico Reservoir.
3.4Q Quaker Bridge Dam (of Croton Reservoir, but not so filed).
Relative advantages of site; availability of, with reference to topographical and geological features, etc. (General. Use tabs, if desired).

3.41 Theory. (Divisions of design.)
.412 Ice thrust.
.413 Upward water pressure.
.414 Vacuum.
.415 Internal stresses.
.416 Temperature. Cracks. Expansion joints. Interior drainage.
.42 Earth Dams or Dike (materials and methods of construction). (Location. Site. Cross-sections. Profiles.) Use tabs to divide if necessary, under 3.42.
.421 Theory (not included under 3.41).
.422 Preparation of foundation excavation.
.423 Earth work of dam, filling, etc.
.424 Core-walls.
.425 Paving and riprap,sodding, slope protection, etc.
.426 Prevention of leakage — drainage.
.43 Masonry Dams, cyclopean, rubble, concrete, etc., not overfall sect. (Materials and methods of construction. Location. Site. Cross-sections. Profiles.) General. Separate under 3.43 if necessary.
.431 Theory (not included under 3.41).
.432 Excavation. Earth and rock. Preparation. Foundation, Faults. Seams. Springs, etc.
.433 Embankment.
.434 Masonry.
.435 Interior drainage.
.436 Gate Houses, if monolithic with dam (piping and appurtenances).
.437 Finishing.
.44 Masonry Dams. Overfall sections, waste weirs. Spillway. (Location. Site. Cross-sections. Profiles. Materials and methods of construction.) General. Separate under 3.44 if necessary.
.441 Theory (not included under 3.41). (Waste channels, capacity of flow, etc.)
.442 Excavation, earth and rock.
.443 Embankment.
.444 Masonry.
.445 Interior Drainage.
.446 Gate Houses.
.447 Special Structures.
.45 Reinforced Concrete and Other Dams (not Cofferdams).
.46 River Control.
.462 Cofferdams and Other Temporary Dams. Cribs.
.463 Flumes (not for general use. Flumes, general, see 5.5).
.464 Pipes. Conduits. Culverts.
.465 Regulating Devices, Gates, etc.

The bearing and effect of the heading, "MADE IN CONNECTION WITH," is well illustrated by the exception in the case of steel pipe for river control at Olive Bridge Dam, which is filed under the proper subdivision of reservoir, namely, 3.464 AO (A, Ashokan; O, Olive Bridge). It is far better to accept the system as applied to general and miscellaneous matter merely as an arbitrary set of numbers corresponding to certain topics, resolutely dismissing rigid ideas of logical sequence and consistency, except in the case of matter relating to the main structures to be built, wherein the logical arrangement can be more closely followed. The list is manifestly incomplete when considering isolated topics, and in most instances it will

not be advisable to establish new integral file numbers for all subjects that come up, but rather to classify them if possible by the general heads which already exist and write a card in the alphabetical index for the particular topic, for the guidance of those uninitiated in the logic of the system, and to aid file clerks in filing similar data under the same head. Later, if the data on any topic increase, a decimal subdivision under the general head can be assigned and collected matter filed there. For example: the topic "Hydraulic Tests of Rock" does not have a distinctive file number, but is filed in 70.0, the file number of "Borings, General," when the boring was not made in connection with a particular structure. "Hydraulic Tests at Olive Bridge Dam Site" could, if desirable, be filed in G 3.4 AO. In the alphabetic index, however, under T we find the heading "Tests, Hydraulic, of Rock," with the file number 70.0 for general information on this subject, and other file numbers in case work of this character was made in connection with one of the main structures and filed there. Later it might appear advantageous to assign some decimal subdivision of 70.0 as the file number for general information on this particular topic.

General.

It is not possible to foresee all cases wherein ambiguity will crop out on application and set down hard and fast rules in advance for guidance of file clerks. Hence the importance of maintaining close communication between file clerks in the field offices and Headquarters is emphasized. As these points come up, they should be referred to the Headquarters office for settlement and, if file clerks have individual opinions, they should state them, giving at the same time reasons for their point of view. The final settlement should be transmitted to all the offices for uniform adoption.

Explanations will be found throughout the numeric index at various points where deemed necessary. These should be read before endeavoring to apply the filing system.

Actual experience with this system has shown that legitimate differences of interpretation of the index are constantly occurring, due to individual point of view, so that in many cases more or less arbitrary or illogical rules must be adopted for the sake of uniformity at these points of uncertain definition. It is obvious that these rules, as well as the index, must be made uniform. As a general principle, therefore, it is expedient to trust the work of filing and indexing to as few persons as condi-

tions will permit, and to avoid local interpretations by referring doubts to Headquarters office for final settlement.

Contract Files.

Separate files are to be provided for each contract, and matter will be further divided and filed by item (where desired) as well as by the file number.

As construction progresses, more data in the engineering bureau will be filed under individual contracts and less in the general file. It will evidently be desirable to have the numbers by which contracts and agreements are to be designated assigned as soon as practicable, so that matter can be marked with contract number and filed in the contract file, otherwise a good deal of preliminary data which viewed in retrospect belongs as properly in the contract file as that originating after the contract number has been fixed will necessarily be filed in the general file.

The method of filing by item and file number admits of two possibilities, namely, division of the item by file number and division of the file number by item. Under cut-and-cover aqueduct, for example, the file number of excavation is 5.23, which may be further subdivided under Contract No. 2 as 5.23 C, Contract No. 2, item No. 1, which reads "Excavation between Stations 100 and 200." Again, under grade tunnel, excavation (5.33 C G, Contract No. 2, item 34) reads enlargement of tunnel section in earth, 5 being the file number of aqueduct, .3 the type of aqueduct called "grade tunnel," .33, "excavation in grade tunnel," C, Catskill aqueduct" and G, "Garrison tunnel." Conversely, a given item of concrete or excavation may be split up by file numbers and apportioned among several structures or parts of the work.

When it is considered that a contract is, as a rule, for one class of work, represented in the index by a single file number (see Contract No. 2; largely "cut-and-cover aqueduct"; file No. 5.2; and "grade tunnel," file No. 5.3) which may or may not be subdivided sufficiently to accommodate the large amount of correspondence and other data that is certain to accumulate during its pursuance, it is a decided advantage to file by item in the contract files. Abstractly, it is quite immaterial whether the segregation is accomplished by file numbers representing certain topics or by item numbers representing the identical topics, the advantage in practice lying with the latter method, viz., in that file numbers for details may be curtailed in the gen-

eral list without sacrificing minute subdivision in the contract files where correspondence, etc., on details accumulates. Moreover, the definition of an item number becomes fixed in the minds of those engaged on contract work, and it is, therefore, not an unnatural division or an unusual line along which to require persons to think. On the contrary, field men will find it a distinct advantage in contract work generally to avoid the duplication of file numbers and items and the necessity of memorizing a confusing relation between them, which would otherwise be the inevitable result.

Just as instructions forbid discussing more than one subject, one contract or one agreement in a letter or other document, it is essential to this method of filing that a communication deal with only one item, and contractors as well as the engineers should be accustomed, by having their attention repeatedly called to transgressions, to follow this method in correspondence. Some data, of course, will be of a general nature wherein several items of a contract or the work in general will be discussed, and these should, of course, be filed by the proper file number in the contract file. In some cases it may happen during the course of a contract that something would come up of value on contracts in general or of important bearing on future contracts, and it would, therefore, be desirable to have this information given in an ALL CONTRACT or GENERAL CONTRACT file and not obscured in the file of any one contract. This can be accomplished by copying the data and filing the copy under CONTRACTS, GENERAL, 72.12, or cross-indexing it on the cards of the general index.

At the head of each contract file a list of the items should be kept as an index, since the item number represents a different topic in each contract.

"Loose leaf" methods have been followed so far as practicable. Useless papers are removed from the files and destroyed from time to time. This, of course, requires care, and doubtful cases are referred by the file clerk to some one in authority. Searches for general information in the libraries of the board and of individuals, as well as in outside libraries, in engineering periodicals and in the manuscript reports in the files are made by a librarian, at considerable economy of time for the engineers and regular filing force.

If the system seems complicated from its completeness and the comprehensiveness of this description, remember that the

organization and works for which it has been devised constitute one of the most extensive, costly and difficult engineering projects ever undertaken.

No more fitting close for this paper can be written than the letter of Chief Engineer J. Waldo Smith, transmitting the book of regulations to the members of the Engineering Bureau: "These general regulations have been prepared to insure uniform and correct methods in all departments of the Engineering Bureau. They must be carefully studied and conscientiously observed. Obviously some details will have to be determined by each department engineer for the peculiar requirements of his work. Special rules, whenever they are necessary, must harmonize with these general instructions.

"Systems will not run themselves. Success depends upon the faithfulness of men. Each member of the force is expected to coöperate loyally with the others in maintaining a high degree of efficiency in all the work of the Bureau."

[NOTE. — Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by January 1, 1910, for publication in a subsequent number of the JOURNAL.]

GOING VALUE AS AN ELEMENT IN THE APPRAISAL OF PUBLIC UTILITY PROPERTIES.

By William H. Bryan, Member Engineers' Club of St. Louis.

[Read before the Club, October 20, 1909.]

Appraisals of public utility plants are made for a variety of purposes — sale, bond issues, taxation — and more often in recent years as a basis for rate-making, a function which is coming more and more to be exercised by state or municipal authorities.

Such appraisals must cover both the tangible and the intangible values. The former present no great difficulty, being usually taken as the present cost of duplicating the property used and useful for the convenience of the public, less depreciation. The intangible values are usually two in number, "franchise" and "going" value.

Where the utility is operating under an existing franchise, future net earnings during the unexpired period are estimated. These, when reduced to present worth, fairly represent franchise value. Where the franchise has expired, or where the municipality has the right to purchase at stipulated periods, there is, of course, no franchise value.

Going value, however, may continue even after the franchise has expired so long as the plant continues to serve the community. This value was first officially recognized in Judge Brewer's decision of the Kansas City Water Works case (see United States Federal Reports, 62–853) in the following language: "The city steps into possession of a property which not only has the ability to earn, but is, in fact, earning. It should pay, therefore, not merely the value of a system which might be made to earn, but that of a system which does earn."

It is an infortunate fact, however, that agreement is still far from general among engineers both as to the exact definition of going value and the proper method of determining its value. This is well illustrated in a recent compilation * of twenty valuations, in which it varies all the way from 0 to 47 per cent. of the

* "Notes on Going Value and Methods for Its Computation," by John W. Alvord, presented at the Milwaukee Convention, American Water Works Association, June, 1909.

physical value of the plant. Even wider ranges would probably be found if all the appraisals in which it has been considered by able engineers of varying view-points could be compiled and compared. In one of the most important appraisals of recent years, in the hands of five of the leading specialists of the country, no two of them agreed as to the method of computation.

There is, however, much evidence indicating that substantial progress is being made towards clearer and fairer views. The author ventures to indulge the hope that it may soon be possible to so handle this matter that the justice and fairness of our methods will be so apparent as to appeal, not only to specialists, but to judges and juries and to mayors and boards of aldermen as well. There must surely be a way to so determine going value as to satisfy both seller and purchaser.

Perhaps the clearest official utterances thus far made on this subject are the recent decisions of the State Railway Commission of Wisconsin. In the Cashton Light and Power Company case they said:

"The element of 'going value' created by the investments made in developing the business and in addition to the cost of the physical structure must be taken into consideration in fixing value; although the franchise of a public utility operating under an indeterminate permit has expired upon the exercise by the municipality of its option to purchase, the plant is to be taken over as a going concern, and just compensation must be awarded for the property taken as a living and operating entity, engaged in serving the public, and not as a mere plant without patrons and without privilege or right to operate and to serve the public and having but a salvage value."

Also in the Antigo water and the Marinette telephone cases:

"The theory of the Wisconsin public utilities law is that rates shall be reasonable and shall be not greater than enough to yield a fair return on the investment. In determining the investment as a preliminary process to the fixing of rates, the Commission had to deal with the claims of large 'intangible' franchise values as well as 'going values,' in both the Antigo water case and the Marinette telephone case. Regarding the former, the Commission holds that if the municipality required the payment of money or its equivalent, or there was necessary legitimate payment made for the franchise, then the sum which may reasonably be said to have been paid for the franchise may be included in the valuation, the same as money necessarily invested in the physical property. But the Commission refuses to consider the claims of some experts and corporations that franchises for which no money was paid may have 'intangible' values which should be considered in the making of rates.

"It has been held by experts that 'going value' should be allowed as so much per customer, or as a percentage of the receipts, and some have considered it of as great, if not greater, importance than the physical value of the plant. The Commission holds that the actual reasonably wise expenditure of money towards getting the business of the plant established may be included in the value to be allowed for the purpose of fixing rates. Since no plant pays at the outset, and the first years of operation are almost invariably accompanied by losses or necessary deficits, the Commission holds that such losses may be said to represent the cost of securing an established or going business, and as such may be included in the value or investment upon which the rates for public service shall be fixed. But the converse of the rule also holds; that is, if a plant has in the past earned more than a reasonable return, possibly through the toleration of excessive rates, the excess over reasonable earnings may, under certain conditions, be subtracted in determining the present value of the plant. That is, a 'going value' may be negative. In the case of the Marinette Telephone Company, for example, the Commission found upon its investigation of the financial history of the company that through a period of recent years the company had been enjoying a sufficiently high rate of return to write off the early deficits in so far as such deficits might be allowed as going value."

It may be noted in passing that the now generally accepted view is that the plant value upon which a fair return must be earned is the present cost of duplicating the existing plant (less depreciation) and not its actual original cost. It is not material, therefore, what the original outlay for franchise may have been, but it *is* important to know what moneys, if any, would now have to be expended to secure such a franchise. Neither are past losses or profits conclusive further than as they throw light upon probable future earnings.

The important facts in the above rulings are that the Wisconsin Commission has officially recognized the propriety of including going value in appraisals and has pointed out that it should be computed as the sum of two outlays:

First, moneys spent directly for getting business; and

Second, moneys advanced to cover losses in the earlier years of operation.

These amounts, of course, are not the sums which the plant under consideration may actually have expended, but the amounts a plant starting to-day would probably have to pay to secure sufficient business to make the plant self-supporting.

Having ascertained the present value of the physical plant, the Commission considers it proper to add to it these two amounts,

the total being the fair value at which the plant might be sold, or upon which the owners are entitled to earn a fair return.

Assuming the existence of the bare physical plant, without connections or business, what additional outlay would be necessary, under the conditions existing at the time of the appraisal, to bring its income up to a point where its losses would cease and it would begin to earn a fair return?

Legitimate expenditures to build up business would cover such items as advertising, circulars, solicitors, special rates or even free service for limited periods, free connections, plumbing at or below cost, etc. Not infrequently solicitors are paid a fixed sum per contract brought in. Such outlays would unquestionably hasten the attachment of services and thus shorten the unproductive period. For a water works it would be proper to take into consideration the present-day general knowledge and appreciation of the advantages of water under pressure, and the fact that it is now a necessity in manufacturing, commercial and domestic life. In any modern city the demand would be immediate and extensive, and the rapidity of securing business would in most cases be limited only by the ability of the working forces to install the plumbing and make the connections. At starting, the plant would have the public revenue from fire hydrants, public buildings, fountains, etc., and soon thereafter the income from a considerable number of private consumers. This would cover a large part of the operating expense, probably half or more. It then remains for the appraiser to estimate the period within which the necessary volume of business would be connected and to compute the probable losses up to that time. This is a matter calling for the trained judgment of a skilled observer. It depends upon the size of the city, the character and habits of the people, their wealth, the number of factories, breweries, railroads, etc., and the quality and quantity of other available supplies, such as wells and cisterns, and many other things.

The physical value of the existing plant is ascertained by estimating the cost of a duplicate plant and deducting depreciation, such cost including, of course, interest, administration, etc., during the construction period. Some engineers hold that as this duplicate plant could not be gotten into actual service for a considerable period, the net earnings of the existing plant during that period are properly a part of going value. The income of the existing plant being limited, however, to a "fair return," there would be no excess earnings, and, therefore, nothing to add. From this standpoint the city's right to purchase in no way affects going value.

The probable operating expense of the "starting plant" may be projected into the future with reasonable accuracy. It must, of course, include not only the ordinary expenditures for labor, fuel, supplies, etc., but also taxes, repairs, administration, interest and depreciation. The growth of income, however, is not so easily estimated, as it involves both the volume of business and the rates charged.

Income depends upon rates. A favorable schedule, not necessarily the highest, will shorten the unproductive period and thus decrease going value. Unwise rates retard growth and increase going value. Attempts to determine going value must, therefore, presuppose some basis of rates. But rate revision, directly or indirectly, is the purpose of most appraisals. To assume rates as a step towards fixing rates is to reason in a circle. What, then, shall be done?

Many appraisers assume that existing rates continue. It is argued that they furnish the only definite data available affecting income. To change them would be to enter upon the problematical. But existing rates may be either too high or too low for a fair return.

The tentative or "cut and try" method would seem much preferable. First compute income and then going value, using existing rates. If that income is more than a fair return, repeat the calculation at a lower rate. If insufficient, try a higher schedule. Continue these trials until a rate is found which will insure a fair return within a reasonable period. The going value on this schedule would seem to be the proper one.

Going value thus determined is clearly independent of whether the franchise has expired or whether the city has the right to purchase. It enters into the appraised value of the plant, just the same as any physical item, at its cost of reproduction.

It is interesting at this point to note the Wisconsin Commission's conclusion that going value may be negative, when later profits above a fair return have more than wiped out the deficits of the earlier years. Is not this a reasonable consideration for the future? Assuming a rate schedule and growth of business which would make the plant self-sustaining within a reasonable period, the normal continuation of that growth would cause the plant to earn profits which would soon offset the earlier losses and thus destroy our measure of going value. It would be within the legitimate power of the authorities to so adjust rates as to bring this about.

The author of the paper above referred to defines the going value of an existing plant as the cost of reproducing the income of that plant. He fixes its amount by computing the difference between the net results of its operation and the net results of a well-conducted "starting plant, through the time necessary to enable the starting plant to be completed and recover an income equal to that of the going plant."

The differences between these views and those now officially promulgated by the Wisconsin Commission, which, by the way, are held by many able engineers, are worthy of serious consideration.

The first difference is one of definition, Mr. Alvord holding that the income, the cost of producing which is to be estimated, is the gross income of the existing plant. The Commission's view is that an income sufficient to meet operating expenses is sufficient. Losses having ceased, further business is secured without cost. Previous losses may properly be called going value and charged to capital account. A greater income is of no interest or value to the municipality, for rates will at once be readjusted to the "fair return" basis, whether the appraisal is for sale or for rate fixing. No city could fairly be asked to pay an inflated "going value" based on an excessive income which it will immediately proceed to reduce. Existing income based on existing rates is, therefore, valueless for this purpose, and may even be misleading, as producing sometimes more, sometimes less, than a fair return.

Viewed from this standpoint, the financial history of the existing plant has only an indirect interest. It may help us to estimate the cost of operation and to form some judgment as to the time within which the starting plant will begin to earn a fair return.

The second difference between Mr. Alvord and the Commission lies in the method of computation. Nowhere does he recognize the direct expenditures for getting business already referred to. He compares the existing plant already doing business as a going concern with a similar "conceptual" plant without business, which would have to be built and put into operation. Meanwhile the business of the existing plant continues its normal growth. He concedes, however, that at some future date the starting plant will acquire an income equal to that to which the existing plant has then grown. The difference in net operating results up to this date comprise, in his opinion, the full measure of going value.

Two perplexities here confront us. The existing plant, with its prestige of years, its standing in the community, its "going value," if you please, would seem to have a permanent advantage. Having usually twenty or more years the start, ought not its continuing growth to keep it permanently ahead of the newer plant? And if there is to be forever a difference in their income, then the going value thus computed must be infinite.

If, however, the "starting plant" is assumed to grow at so rapid a rate that in a few years its income equals that of the existing plant, why should that rate of growth then suddenly drop to that of the existing plant? Will not the same conditions which have caused its previous rapid growth continue? If they do, thenceforward there would be an excess of income which would soon wipe out the earlier shortages, as has been well pointed out by the Wisconsin Commission.

A system of computing going value whose results may range all the way from zero to infinity is not pleasant to contemplate. But these difficulties vanish when the "fair return" income, and not the existing income, is taken as the basis.

The above method might fairly measure the increased worth of the existing system to a private purchaser as compared with a prospective plant without business, assuming a continuance of rates and income. But such assumption cannot be made in the case of municipalities (except where unexpired franchises exist), as the ultimate purpose of practically all investigations of this kind is rate revision. Furthermore, the *cost* of reproduction is the ruling condition, not the value of the thing reproduced, exactly as is the case with a pumping engine or any other feature of the physical plant.

Many attempts have been made to compute going value along similar lines, although but few have followed the exact definitions given. In some such comparisons interest and depreciation during the construction period have been assumed equal on the existing and starting plants, while they should not be charged against the starting plant at all. There is no depreciation prior to the start, and interest is always included in the construction account.

This, however, brings up another matter. As has been well said, it is not fair to substitute hindsight for foresight. No designer can foresee all possible contingencies; no engineer is infallible. Mistakes have always been made, and always will be. Boilers, engines, standpipes, buildings, reservoirs, purification systems, even sources of supply, have failed, necessitating re-

moval and, in some cases, abandonment of entire plants. Sometimes the city has not grown in the direction originally expected. Even the most capable and experienced designers, associated with men of the soundest business judgment, have encountered such disasters. It is a hazard of the business. If a new plant were begun to-morrow either by private parties or the municipality, this risk, in greater or lesser degree, would necessarily inhere in it.

No fair-minded appraiser, however, would include allowance for such mistakes, however unavoidable. The city cannot fairly be asked to purchase at or pay rates on values so determined. But does not the fact that the existing plant has, as it were, "sown its wild oats," has discarded its unwise and useless equipment and has demonstrated the fitness of its remaining parts, make it of more value than a new plant with that unavoidable experience still to go through?

The author confesses to some uncertainty as to just where this factor should appear, but that it is an element which should not be overlooked he is certain. For lack of a better place he suggests that it have its weight as one of the "contingencies" in fixing the percentage to be added to the cost of reproduction. In the average case, however, its value would not be large.

What should be the attitude of the conscientious appraiser towards those plants which are losing money? Has such a plant a going value? This question has been answered in all seriousness in the affirmative. It has been held that an established plant would lose less money than one with its business still being developed. Under Mr. Alvord's method the excess in loss of the "starting" over the existing plant would measure the going value. The Wisconsin Commission plan could not, of course, be applied, as the continuing losses would make the going value unlimited. Under these circumstances there may be several views:

1. A study of the situation may show that the normal growth of the business will soon end the losses.

2. The losses may be decreased, and in due time ended, by some reasonable advance in rates. In both of these cases the Wisconsin rule could safely be applied.

3. If, however, the situation is such that there appears to be no reasonable way to make the plant earn a fair return, the solution becomes complex.

Such cases, unfortunately, are not uncommon, particularly in smaller cities and in undeveloped or boom territory.

Sometimes both the city and the owners have been over-sanguine as to the future. Many cities have in times of enthusiasm and prosperity been induced by energetic promoters to enter into contracts for service which have later proved exceedingly unwise for all parties concerned. Business has not developed, nor has the place grown as anticipated. Important industries may have ceased; opposition towns or railroads may have taken the business away.

While the plant is losing money at the existing rates, it is nearly always true that these rates, both public and private, are a serious strain on the limited resources of the city and its people. No advance is, therefore. possible; it may even be impossible to maintain existing rates. Not infrequently the expiration of the contract is looked forward to as a date when relief may be expected.

Such contracts are usually for periods of twenty to thirty years. Usually all obligations between the parties end with the expiration of the contract. There seems no escape from the conclusion that the owners of the plant must accept the situation as it then exists. As they would have been entitled to the profits of a successful plant, so also must they accept the losses of the unprofitable one. If the cost of service is beyond its means, the city is at liberty to discontinue it. If the contract made no provision for extensions, or if such provisions were illegal, the plant has no rights superior to those of the municipality. It is to be presumed that the owners knowingly took the risk of securing, within the contract period, such returns as were necessary.

This view is, of course, hard on the invested capital, but the law very wisely prohibits municipalities from incurring obligations which may prove onerous to future generations. Posterity should not be made to suffer through the errors of earlier days. In some cases it has been held that, owing to the uncertainties attending the situation at the end of the contract, the "fair return" basis entitled the owners to rates which would make the earnings sufficient to retire the entire investment, less scrap value, within the contract period. This interpretation, however, is very rare. It has a counterpart in those states which require the establishment of sinking funds by municipally owned plants to retire the bond issue within a definite period, usually much less than the life of the plant.

The problem then is, not whether a going value should be included in the value of the plant, but to determine a value

which the maximum income possible under the existing circumstances will support. In other words, the actual worth of the service to the community fixes a limit to the value of the plant, beyond which no figures, however elaborate or logical, can go.

Under a strict interpretation of either the Alvord or the Wisconsin theory, the city would be required to purchase the plant at a valuation, or pay rates giving a fair return on a valuation, based on cost of duplication less depreciation plus going value. The latter, on account of the slow building up of the business, would be large.

Clearly, however, this would be unfair to the city, as involving prohibitory rates, rates which the public service could not stand, and which would discourage private consumption and prohibit growth, thus minimizing private revenue. The difference could not be made up by increased taxation, as this is limited by law.

We may, of course, take the broad stand that if a city wants water works it must pay the price; they cannot be run as charitable institutions. But there is a limit to the city's ability to pay. Is it not true, therefore, that the plant, in order to continue to serve the community, must be willing to adjust its rates to a basis which the people can pay? Would not any other course necessarily end in forcing the city to discontinue a service beyond its means, a result disastrous to all concerned?

Evidently the construction of a plant at all in such a location was a mistake on both sides. Is it not the clear duty of the appraiser in such cases to eliminate, on the one hand, every possible element of questionable value and to get his figures down to bed rock, in the hope of finding a way to meet the exigencies of the situation, and, on the other hand, to see that the city acts in equal good faith, that it properly appreciates the full value of a good supply and apportions the maximum amount possible to that service? It is worth remembering that in many cases the lowering of private rates to points originally considered suicidal has so attracted consumers as to materially increase both gross and net income.

Evidently in such unfortunate cases the situation demands a valuation quite apart from the actual physical plus the going values, however just those values may be in the abstract. Fairness to the municipality is not less essential than fairness to the plant. The courts have decided that while such regulations are intended to be mutually fair, they must in any event be fair to the city.

Clearly such reasoning is only effective when the city is prepared for the alternative of abandoning the service. If it is so situated that it cannot do without the service, then it must find a way to pay a fair return for it. But in no event can the value of such a service exceed the cost of getting that service in some other way.

Further perplexities are often found. It has been questioned by many fair-minded men whether the plant, after all, has any ownership of the business on which going value is based. Should the people pay for what they have themselves furnished? Certainly such value can go no further than the actual cost of reproducing that business.

It will be noticed that both the Alvord and Wisconsin methods give the greatest going value to those plants which have had the longest and hardest struggles to build up their business, while such plants are actually worth the least as commercial propositions. Prosperous plants, with large business quickly established, have the least going value, though far more attractive to the investor. The same is true as regards rates. A high schedule usually means low going value, while low rates increase going value.

With such wide divergencies of opinion among thoughtful and fair-minded men, it is not strange that much effort has been devoted to the finding of better and simpler methods. Nor is it strange that, despairing of success, shorter methods, less logical, perhaps, but giving due recognition to the underlying principle, should find favor. Some of these may be noted:

In one of the most important cases of recent years, in the hands of men of great ability, the results of various methods of computation were all found to be reasonably close to one year's gross revenue, and that sum was finally agreed upon.

In the recent Staten Island case * the going value was arbitrarily fixed at $10 per service.

In Canada a flat addition of 10 per cent. is made to the physical value to cover all the intangible values. See Municipal Acts of Ontario, third edition, VII, chapter 19, section 566, subsection 4, clause (a2), which reads:

"In any arbitration under Clause (a) hereof to determine the price to be paid for the works and property of a gas or water company, the arbitrators shall determine the actual value of

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* "Acquisition by New York City of the Larger Two-Water Systems of Staten Island," by L. L. Tribus, Milwaukee meeting, American Water Works Association, June, 1909.

such works and property, having regard to what the same would cost if the works should be then constructed or the property then bought, making due allowance for deterioration and wear and tear, and making all other proper allowances, but not allowing anything for prospective profits or franchise, and shall increase the amount so ascertained by 10 per cent. thereof, and such increased amount shall be the amount which the arbitrator or arbitrators shall award as the price to be allowed for the said works and property."

In drawing a new water contract at Mexico, Mo., the author recently adopted a somewhat similar idea, as follows:

"PURCHASE BY CITY. The city shall have the right to acquire by purchase all the property of the grantee actually used and useful for the convenience of the public at any time after the expiration of fifteen (15) years from the passage and approval of this ordinance by public vote, upon giving one year's notice to the grantee and upon paying therefor in cash the then cost of duplication, less depreciation of said property, with ten per cent. (10 per cent.) additional thereto as compensation for earning power, franchise value, going value, contingencies and all other intangible values of every nature whatsoever."

Mr. Alvord's concluding remarks indicate a preference for using the actual cost of the existing plant, where it can be ascertained, as the basis of fixing rates, rather than the present cost of reproduction less depreciation, because of the exceeding complexity of the computations. It may be questioned whether many appraisers will follow him here. The idea is fundamental that present values and rates must be based on present-day conditions. Nor is it usually difficult for able, experienced and fair-minded appraisers to agree with reasonable closeness on physical values.

When the intangible values are taken up, the situation, as has been shown, is far different. Here, if anywhere, simple and direct methods, appealing more strongly to the average man's ideas of fairness, are needed. And from this standpoint the simple methods used above are not without merit.

[NOTE. — Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by January 1, 1910, for publication in a subsequent number of the JOURNAL.]

JULIUS WILLIAM SCHAUB. A MEMORIAL.

By Edward Flad, Member of the Engineers' Club of St. Louis.

[Read before the Club, October 6, 1909.]

Julius William Schaub was born in St. Louis, Mo., on September 23, 1859. He was the only son of Henry Schaub and Susan Orb, both of whom were born in Germany. His death occurred March 30, 1909. He had been suffering from ill health for several years and had taken a rest cure and treatment at Muldoon's Sanitarium at White Plains, N. Y., from which he appeared to derive much benefit. A second visit to the same sanitarium resulted in a firm conviction on his part that he was doomed to remain an invalid. After a stay of about a week at the sanitarium he wrote to his wife, who was at their home in Chicago, to expect him home on the afternoon of March 30. While on his return trip on the fast west-bound Michigan Central Train No. 9, he came to his death in the toilet room of the car in which he was traveling. His dead body, with a revolver on the floor by his side, was discovered by the train porter just after the train left Kalamazoo, Mich. He had last been seen alive when the train passed through Battle Creek, Mich.

Schaub received his early education in the public schools at St. Louis, entered Washington University, St. Louis, in 1878, and graduated from that institution with the degree of Civil Engineer in 1881.

For his graduation thesis Schaub selected the subject, "The St. Charles Bridge." I remember being one of the boys who went to St. Charles in charge of Prof. Charles A. Smith to measure up the details of the bridge and obtain material for Schaub's thesis. He was a good worker as a student, and early displayed those qualities of close application to the problem in hand and interest in his work which in after years brought him recognition in his chosen profession.

Schaub's first employment was in the office of Col. C. Shaler Smith at St. Louis. Shaler Smith had designed the St. Charles Bridge and was one of the foremost bridge engineers of that time. Here Schaub obtained his first practical lessons in bridge designing and bridge construction.

In the spring of 1882 Schaub was sent by Shaler Smith to

the Edgmoor Iron Works, near Wilmington, Del., as inspector on bridge-work. He retained that position for two or three years. His shop training at the university had especially fitted him for inspection work and he received unusual consideration from shop men, who had grown accustomed to the inspection of engineering graduates who had had no shop experience.

He remained with C. Shaler Smith from 1881 to 1886. From 1887 to 1892 he was chief engineer of the Detroit Bridge and Iron Works. His fairness and generosity are well illustrated by an account by George H. Pegram of a meeting with Schaub in the fall of 1888, when Schaub was chief engineer of the Detroit Bridge and Iron Works. Pegram writes as follows:

"I had obtained a price from the Edgmoor Iron Company to enable me to make a tender on my patented bridge to the Missouri Pacific Railway, and stopped off at Detroit to see Schaub on my way to St. Louis. When I showed him my plan and the tender I was going to present, he laughed and told me that they were going to bid for the same bridge at a considerably lower figure, with a fair chance of getting the work. I then asked him to give me figures on my plan, making a fair comparison with his own, that I might use in competition. He gave me a price less than his own, contending that the cost of shop work, etc., was much cheaper on my plan. I bid on the bridge and got the contract, which otherwise would have gone to them, as they were the next highest bidder. I have never received more generous and noble treatment."

In 1893 Schaub became chief engineer and manager of the Pottsville Iron and Steel Company, and from 1895 to 1897 he held a similar position with the Hamilton Bridge Works, of Hamilton, Ont., Canada.

In 1898 he established an office in Chicago as consulting engineer, being engaged largely in bridge and structural steel work, serving in this capacity a number of important railways. With the development of reinforced concrete he devoted considerable attention to the use of this material for structural purposes. He had patented a reinforced concrete caisson system for deep foundations (noted below) and a floor system in which each panel acted as a groined arch. He had designed also a reinforced concrete roadbed for railways, with modifications for use on bridges and in tunnels, and this was described by him in *Engineering News*, November 2, 1905.

In 1900 he was engaged by the St. Louis & Southwestern Railway to report upon its bridges. He made a personal examination of every bridge on the system, and prepared plans for

the strengthening necessary to adapt the bridges to the increased loads. In 1903 this railway took over a narrow-gage road in Arkansas which had a bridge crossing the White River at Clarendon, Ark. There was some question as to the stability of the cylinder piers under the increased loading, as there was no information as to their penetration. The method of strengthening devised and carried out by Schaub was to surround each old pier with a concrete caisson which was sunk to a greater depth than the old cylinders and became a part of the new pier. The two rest piers (for two fixed spans) consisted each of a pair of 6-ft. cylinders; both cylinders were inclosed in a new rectangular caisson about 12 by 38 ft. The pivot pier of the 355 ft. swing span had six 4-ft. cylinders arranged in the form of a hexagon, and a central 6-ft. cylinder; these were all included in a 33-ft. circular caisson of reinforced concrete 18 in. thick. The space within the rectangular caissons was filled with concrete, but that within the circular caisson was filled with sand.

Schaub was consulting engineer also for the new bridge of the same railway crossing the Red River at Shreveport, La., including both the substructure and the superstructure. This was commenced in 1904 and completed in March, 1907. It has four fixed spans of 200 ft., one of 150 ft. and a swing span of 300 ft. One of the notable features of this work was that the pier foundations were sunk to depths of from 60 ft. to 80 ft. by open cofferdams of reinforced concrete, on Schaub's patented system. He did a considerable amount of work for Mr. H. G. Kelly, member American Society of Civil Engineers, while the latter was chief engineer of the Minneapolis & St. Louis Railway, and later when he became chief engineer of the Grand Trunk Railway. One of Schaub's latest works was the design of a very large swing-bridge for the Grand Trunk Railway at Black Rock Harbor, Buffalo, N. Y., to form a part of the International Bridge. This will have a length of 451 ft. 5 in., and will carry two railway tracks and two roadways; it will be operated by electric power.

His work was not entirely in the line of bridges, however. In 1901 he was consulting engineer for the St. Louis, Iron Mountain & Southern Railway in connection with the design and construction of its new shops at Little Rock, Ark. In 1903 he had a similar engagement with the Missouri Pacific Railway for its extensive locomotive and car shops at Sedalia, Mo.; the plant included some fifteen or sixteen buildings, with a machine and erecting shop 752 by 135 ft.

Schaub became a junior of the American Society of Civil

Engineers in 1884, and was elected a member in 1886. He was a non-resident member of the Engineers' Club of St. Louis from 1888 to 1905. He became a member of the Western Society of Engineers in 1902. He was a member also of the American Railway Engineering and Maintenance of Way Association, and of the Engineers' Club of Chicago. He wrote a number of papers for engineering societies and the technical papers, and took part also in many discussions on matters relating to his particular lines of study. His name has appeared many times in the *Engineering News* in connection with articles and letters. Some of his writings are: "The Detroit Union Depot Viaduct," Transactions of the American Society of Civil Engineers, May, 1893; "Proposed Specifications for Railway Bridges," Proceedings of the Western Society of Engineers, October, 1900 (and *Engineering News*, October 11, 1900); "Diagram for Obtaining the Percentage of Steel and Moment of Resistance of Reinforced Concrete Beams," *Engineering News*, April 30, 1903; "Some Phenomena of the Adhesion of Steel and Concrete" (from a lecture delivered at the Armour Institute of Technology), *Engineering News*, June 16, 1904; "Concrete Floors for Railway Bridges and Tracks," *Engineering News*, November 2, 1905; "The Railway Track of the Past and Its Possible Development in the Future," *Journal of the Western Society of Engineers*, May, 1907 (and *Engineering News*, June 13, 1907).

In 1893 Schaub was married to Miss Harriet Holmes, of Lock Haven, Penn. No children resulted from the union. His wife and his sister (Mrs. Emma Rauch, of St. Louis) survive him.

Schaub was a genial man, of a sociable disposition, and devoted to his friends. He had marked ability as an engineer and was not content to follow along in the well-beaten paths of his profession, but led the way to new methods and advanced ideas in the design of the works on which he was engaged.

His friends mourn his death, the loss of his friendly greeting and ready sympathy. The profession suffers a distinct loss in the untimely taking away of an engineer of high ideals, of broad experiences and brilliant attainments.

OBITUARY.

Arthur Ward Hunking.

Member, Boston Society of Civil Engineers.

Arthur Ward Hunking, the only child of Elihu and Elizabeth Smith (Nash) Hunking, was born in Haverhill, Mass., September 1, 1851, and died at Helena, Mont., November 12, 1908. Losing his own mother a few days after his birth, he knew for his earliest recollection a mother's care in the person of his stepmother, Esther (McCurdy) Hunking, who came to his home and nurtured him when he was about two years old. He was cared for in his days of infancy by his aunt, Amelia Baker, his father's sister.

He spent his childhood and young manhood in the city of Haverhill, attending the public schools and graduating from the high school with the class of 1868, " a large and talented class."

His father, in company with his uncle, was a prosperous shoe manufacturer before and during the Civil War times, and Arthur, as a lad, was more or less acquainted with successful shoe-shop work and methods, and was of considerable help and " quite handy " at odd times and during vacations. Here he doubtless acquired or developed the habits of system and organization in the management of business which he exhibited to considerable advantage in later years.

Upon graduating from high school, he entered the civil engineering course at the Massachusetts Institute of Technology, joining the class of 1872, and continuing as a special student for the years 1868–69, 1869–70, and 1870–71.

Soon after leaving the Institute he was for several years engaged in general engineering with Clemens Herschel, C. E., first at the office near the head of State Street in Boston, and later his name appeared on a sign in connection with Mr. Herschel's, on Bartlett's Building, opposite the railroad station at Green Street, Jamaica Plain, where Mr. Herschel had for some years resided, and where he and young Mr. Hunking had good prospects of establishing a surveying and engineering business that would develop with the growing community.

It was here and at this time that Mr. Hunking, with the brightest prospects of youth and ability before him, met with a

sudden and almost overwhelming misfortune that affected his life for many years and quenched his courage to continue the office and work at Jamaica Plain. He had married, in 1873, Miss Ella F. Thacher, of Haverhill, formerly of Sacramento, Cal.; had started housekeeping in the pleasant village of Jamaica Plain, and had been blessed with a little boy, Arthur R., when, hardly more than a week after the son's birth, the mother was taken away with quick consumption, leaving him alone with the infant son, who survived his mother but a little more than a year, dying at the grandparents' home in Haverhill in January, 1875.

During these years of service with Mr. Herschel, Mr. Hunking was earning a reputation in business which rated him in quoted words "as eminently trustworthy and faithful."

After a year or so of general engineering work on several small jobs in the neighborhood of Haverhill, he having returned to his father's roof after the breaking up of the home at Jamaica Plain, Mr. Hunking, in May, 1876, came to the office of the Proprietors of the Locks and Canals on Merrimac River in Lowell as an assistant engineer under Mr. James B. Francis, and entered into the work of that concern with interest and enthusiasm.

He learned the various methods and principles of that master hydraulician, and proved an efficient assistant in the many duties of the place.

Besides posting himself on the measurement and management of the distribution of the water of the river-flow, which is the principal duty of the water power company here, Mr. Hunking applied himself to the problems of fire-protection and took a prominent part in the design and installation of the systems of perforated pipe sprinklers then in very general vogue in the mills of Lowell. Brief accounts of the details of the system may be found in the *Franklin Institute Journal*, April, 1865, and August, 1878, the latter article being by the pen of J. P. Frizell, C. E., under whom Mr. Hunking spent several weeks to familiarize himself with the application of the mathematics and graphics of the problem.

While busy in this and in kindred lines of engineering at Lowell, Mr. Hunking became exposed to an attack of the Leadville fever, which was spreading in violence over the East, and which located three cases in the Locks and Canals office. Mr. Hunking, feeling that a wider opening and broader prospects awaited him in the far West, determined to try his chances for them.

Having married, in January, 1880, Miss Sarah F. Parker, of Chelmsford, an old-time playmate of his, he, a month later, started for Leadville in company with Edmund S. Davis and Arthur I. Fonda, engineer companions from the Locks and Canals office. He found occupation at once in the office of Stowell & Frank, United States deputy mineral surveyors in Leadville, where he stayed about three months surveying mining claims in the vicinity, his wife meanwhile, at her father's home in Chelmsford, awaiting his settling down permanently before following him.

But his former employer and partner, Mr. Herschel, finding that he had cut loose from the Locks and Canals Company, and being in especial want of just such a "faithful and trustworthy assistant" as he knew him to be, and because his experience at Lowell had further fitted him for the particular position he had in mind, persuaded him to return East and take the office of principal assistant hydraulic engineer under him at the Holyoke Water Power Company.

The company here had just started to reorganize its methods of measuring and distributing the water-power of the Connecticut River to the various mills and manufactories holding rights or privileges of different kinds to the river flow, and Mr. Hunking was just the man to adapt and apply there the methods and system which had been so thoroughly worked out and experimented with at Lowell.

Having determined the capacities of the numerous water wheels of the mills, and the quantities of water used in other manners, they inaugurated a system of water-wheel measurements and a scheme of distribution which received the unqualified approval of the superior officers of the company and its customers for water power and water privileges.

He was not to remain here long, however, for before the fall had fairly commenced he was prevailed upon by Mr. James B. Francis, of the Locks and Canals Company, to return to Lowell to its employ and assume the charge of the hydraulic part of its work, so that Colonel Francis, the principal assistant engineer, could devote himself mainly to the land business of the corporation, which had then grown to considerable dimensions and was in great need of rearrangement and systematizing.

Mr. Hunking reëntered upon the work for the Locks and Canals with earnestness and enthusiasm, and maintained the same order, system and efficiency that the older Mr. Francis had inaugurated years before.

In 1883, while managing the experiment on the Humphrey turbine water wheel at the Tremont and Suffolk mills in Lowell, and the subsequent experiments on the flow of water over submerged weirs, under the direction of Mr. J. B. Francis, who depended upon him in a very large measure for the accuracy and elaborateness of the tests, Mr. Hunking, coincidently with an assistant, became impressed with the possibility of avoiding a large part of the seemingly necessary work in calculating the weir quantities by the standard Francis formula, adapted for a considerable velocity of approach, and both he and his assistant, by different methods of reasoning, arrived independently and without knowledge of each other's meditations at the conclusion that the velocity-of-approach correction in the above-mentioned formula was a definite and simple function of the relative proportion between the areas of water section at the crest of the weir and at the point of observation of the depths of flow over the weir.

A casual remark of the assistant encouraged Mr. Hunking to work out his ideas, and the labors of the two were combined, condensed and finally published by him in the *Franklin Institute Journal* in August, 1884.

Mr. Hunking's thoroughness in the treatment of work is exhibited in this short article, for he not only gives a refined mathematical formula, but he adds a table, suggests a curve, offers a close approximation easily calculated, and ends with a roughly approximate method (quite inside the limits of practice) that may be worked out mentally. His examples, quoted at the close, finish his argument and the case.

In January, 1885, Mr. Hunking was elected principal assistant engineer by the directors of the Proprietors of the Locks and Canals, his predecessor, Colonel Francis, taking the position of chief engineer and agent, and the senior Mr. Francis, who had then served the Proprietors for fifty years, most of the time as agent and engineer, was made consulting engineer, and was considerably relieved of much of the routine responsibilities which he had previously so acceptably borne.

When the serious and disabling accident in 1888 befell Colonel Francis, and much doubt was in all minds as to his chances of recovery, Mr. Hunking took a great part of his duties, ably seconding the consulting engineer, who stood ready, if necessary, to take up the duties he had laid off a few years previously. The fact that his father had such an able assistant to share the work greatly eased the mind of Colonel Francis during his protracted disability and convalescence.

Later, when Colonel Francis was at work on a scheme for the rearrangement and adjustment of the water-power, rights, uses and privileges on the Concord River at Whipples' Falls, Lowell, which had been involved in lengthy lawsuits, the problem having been given to him by the court to straighten out, he found in Mr. Hunking an assistant of great help and valued counsel, upon whom he relied for much of his measurements and conclusions.

Meanwhile Mr. Hunking was approached by those who had interests and opportunities in water-power management or development, but though he gave them due consideration, yet for one reason or another no change was decided upon. In some of the cases it may have been that the persons having in charge the management of the enterprises, being friends of Mr. Francis, felt unwilling to take from him, without his freest consent, his most valued and indispensable assistant.

However, after Mr. Hunking had managed a very acceptable experimental test of one of a set of six Victor turbines for the Tremont and Suffolk mills, in 1890, the Stillwell & Bierce Company, makers of the turbines, being very much pleased with his ability and the straightforwardness of his management, concluded that they had found a man that they wanted and made him an offer to go into their turbine wheel department. He accepted, and after a few months spent at their shops in Dayton, Ohio, making himself acquainted with their methods and the details of the work, he took the field, visited the mills and sites for projected water wheel installations, studied their particular needs, and made designs and estimates for putting in the plant called for. In the spring of 1893 he was on hand near Fresno, Cal., with a proposition for ten pairs of Victor wheels of 133 h. p. each (an aggregate of 2 660 h. p.) to provide pumping power for the Sunset Irrigation District, for watering 300 000 acres on Kings River, Fresno County.

In June, 1893, he left the employ of the water wheel concern to take a position with the Philadelphia Manufacturers Mutual Fire Insurance Company.

In January, 1895, at the strong recommendation of Colonel Francis, he was engaged by parties interested in and connected with the Massachusetts Cotton Mills, of Lowell, to supervise the erection of the first mill of the "Massachusetts Mills in Georgia," at Lindale, near Rome, and after its erection and fitting out he continued in charge of the work of manufacturing, as agent and general manager, until February, 1899.

A few months later he took charge of the erection of the Merrimac Manufacturing Company's first mill at Huntsville, Ala., and continued there for about two years.

Later he was the resident engineer for the Greenfield Electric Light Company, developing its water-powers on the Deerfield River at West Deerfield and Shelburne Falls. He commenced the work at West Deerfield July 2, 1902. After making soundings and doing some preliminary work, this site was abandoned, as satisfactory foundations would be too costly. On August 1, 1903, the work of developing the power at Shelburne Falls was commenced under his supervision, and completed in October, 1904.

In March, 1905, he was employed by the Stone & Webster Engineering Corporation as resident hydraulic engineer on a large concrete dam about to be built across the river at St. Croix Falls, Wis. He remained there about a year, when he was transferred to take charge of surveys for an important work at Columbus, Ga., a dam across the Chattahoochee River, where much especially difficult work was called for on account of the character of the country, which required the careful consideration of several proposed locations.

In July, 1908, he was appointed hydraulic engineer of the Stone & Webster Corporation in charge of the reconstruction of the noted Hauser Lake dam, near Helena, Mont., and was actively engaged in this undertaking at the time of his death, which came suddenly.

His illness began on Sunday, November 8, and was apparently slight for a few days, but by Wednesday serious fears were excited, and he passed away Thursday, November 12. His only son, Mr. Sidney H. Hunking, also engaged by the Stone & Webster Company on the Hauser Lake work, was able to be with his father during his last days.

Mr. Hunking leaves a wife, a son, above mentioned, and a daughter, Miss Blanche B. Hunking.

He was a Knight Templar, a member of Masonic orders in St. Croix Falls, Wis., and in Columbus, Ga., and the Masonic Club of Lowell. He was a member of the Montana Club, Helena, and of the New England Water Works Association.

His membership with our Society dates from May 30, 1885. His only contribution to the literature of our society is the paper on "Water Power Equipment," read in November and December, 1893.

Mr. Hunking, on account of conditions of residence and

work, was not particularly well known to the greater portion of our members, especially those of the younger generation, and as he was of a quiet and reserved disposition, not many of the older members outside of the water works and hydraulic practice were likely to meet him and form his acquaintance. Those who have met him and known him will not be surprised at some of the high testimonials that the writer has received in answer to inquiries for data and information for the compiling of this memoir.

The writer feels the most positive assurance that, were Mr. Francis, Senior, and Colonel Francis alive, each would express the highest testimonials to Mr. Hunking's character and ability.

His last employers say that "his work while with us was always thorough and accurate, and the respect and esteem in which he was held by all with whom he came in contact was constantly growing," and "he had rendered services and formed associations of a character to make his loss keenly felt."

And from those who worked under him the writer has personally received many expressions of cordial appreciation of his dealings with them which only the truly kind, considerate and unselfish employer can expect to receive and be worthy of.

These latter testimonials can be summed up in no better shape than by quoting from a brother engineer, not a member of our Society, one who has had long and close acquaintance with Mr. Hunking.

He writes as follows:

"For more than thirty years Mr. Hunking was my friend, and I was perhaps nearer to him than any other man. I usually saw him whenever he came home, and in all my acquaintance with him I always found him to be cordial, polite, thoughtful and unselfish, a man whose friendship was worth having.

"He was a man of such dignity that he always expressed himself in plain English, in a manner that was simple, lucid and forceful, with none of the embellishments of vulgarity or profanity such as many smaller men seem to think necessary.

"He was a skillful engineer, and, what is vastly more important, he was a gentleman."

FRANK S. HART, *Committee.*

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REFUSE DISPOSAL, AND THE NEW REFUSE INCINERATION PLANT FOR MILWAUKEE.

By Samuel A. Greeley, Resident Engineer.

[Read before the Engineers' Society of Milwaukee, May 12, 1909.]

In December, 1907, Mr. Rudolph Hering, consulting engineer, presented a report to the mayor and common council of the city of Milwaukee dealing with the problem of the disposal of the refuse of the city. This report presented data relative to the quantity and character of the refuse, and fully discussed the various methods of refuse disposal. Based on the investigations described in the report, Mr. Hering recommended "as a first installment a plant capable of incinerating 300 tons daily, costing $200 000."

This report was accepted by the city council, and Mr. Hering was engaged to prepare plans and specifications for the work. Bids were called for in accordance with these plans and specifications, and on April 3, 1909, the contract for a 300-ton refuse incineration plant was awarded to the Power Specialty Company of New York. Their contract with the city includes the excavation, piling, concrete, furnaces, boilers, flues, cranes and machinery for the plant. It does not include the chimney or the superstructure for the plant, these parts of the work having been let under separate contracts. The total amount of all the contracts foots up to slightly less than $200 000. The actual work of construction is now under way. Hering and Fuller, Consulting Engineers, 170 Broadway, New York City, have been engaged by the city to supervise the construction of the plant. It is

expected that the plant will be in operation early in the spring of 1910.

The purpose of the plant is to burn refuse completely, without nuisance and at an average temperature of 1 500 degrees fahr. The design and development of such a plant fundamentally involve some knowledge of the character of the material to be burned.

According to the specifications, refuse is defined as being a mixture of garbage, ashes, rubbish, manure and small dead animals. These are the chief constituents of city refuse. The composition and character of such refuse varies from season to season, and even from day to day. Nevertheless, limiting conditions may be determined which control the design. Thus in winter, when the percentage of ashes in the refuse is high, the clinker produced in burning the refuse will be the greatest, and its handling will be most difficult. In the summer, on the other hand, the clinkering will be easier work, but the maintenance of a high temperature will be difficult, on account of the high proportion of wet garbage in the refuse. The rate of combustion will be low, and the capacity of the plant will be based on summer conditions. Following are the compositions of ashes, manure, garbage and rubbish as they were used in working out the plans for this work. They are briefly compared with analyses determined elsewhere.

Ashes.

Ashes are either steam ashes, such as come from large boiler plants, or are household ashes. They contain about 15 per cent. of water, 10 per cent. of volatile matter, 50 per cent. of true ash and 25 per cent. of carbon. Ashes analyzed in Pittsburg, for a report by Mr. Hering, contained on the average 7 per cent. of water, 10 per cent. of volatile matter, 58 per cent. of true ash and 25 per cent. of carbon. The average chemical analysis of ashes given in the "Report of Commission on Street Cleaning and Waste Disposal, the City of New York, 1907," is 27 per cent. of water, 8 per cent. of volatile matter, 53 per cent. of true ash and 18 per cent. of carbon. This ash contains a rather high percentage of water. The calorific value of ashes is about 3 700 B.t.u. per pound.

Manure.

Manure is the cleanings from stables. I know of no chemical analysis of manure. In El Paso, Tex., it has been used as a fuel under boilers. It has been assumed that it contains 40 per

cent. of water, 25 per cent. of volatile matter, 15 per cent. of true ash and 20 per cent. of carbon. One of the bidders for the work here based his guarantee for temperature and evaporation on a composition of 70 per cent. water, 13 per cent. of volatile matter, 4 per cent. of true ash and 13 per cent. carbon. The calorific value of manure is, therefore, about 2 700 B.t.u. per pound.

Garbage.

Garbage is the waste from kitchens, restaurants, butcher shops, hotels, etc. It has been chemically analyzed in Milwaukee and in several other places. The results of the analysis in Milwaukee were 78 per cent. of water, 14 per cent. of ash and 8 per cent. of combustible. Analyses made in New York by the Commission on Street Cleaning gave an average chemical content of 69 per cent. water, 22 per cent. volatile matter, 5 per cent. ash and 4 per cent. carbon. The tests made by Mr. J. T. Fetherstone at West New Brighton, N. Y., showed an average composition of 73 per cent. water, 17 per cent. volatile matter, 5 per cent. ash and 5 per cent. carbon. The calorific value is not far from 2 000 B.t.u. per pound.

Rubbish.

Rubbish contains papers, wood, rags, bedding, leather, glass, metals, sweepings from stores and offices, and litter of a similar nature. The composition taken for Milwaukee is 15 per cent. of water, 45 per cent. volatile matter, 15 per cent. ash and 25 per cent. carbon. One of the bidders for the work at Milwaukee assumed a composition of 8 per cent. water, 38 per cent. volatile matter, 14 per cent. ash and 40 per cent. carbon. Tests by Mr. Fetherstone at West New Brighton gave an average composition of 6 per cent. water, 65 per cent. volatile matter, 14 per cent. ash and 15 per cent. carbon. Analyses made by the Commission on Street Cleaning of New York gave 12 per cent. water, 40 per cent. volatile matter, 8 per cent. ash and 40 per cent. carbon. The calorific value of rubbish may vary from 5 000 B.t.u. to 7 500 B.t.u. per pound.

Refuse.

The mixture of these component parts and of small dead animals is defined as refuse. The proportions in which these components enter into the mass of refuse have been carefully measured and are given for the various seasons in the following table:

TABLE 1.

	Summer. Per Cent.	Winter. Per Cent.	Average for Year. Per Cent.
Garbage	57	31	41
Ashes	30	60	41
Rubbish	5	6	5
Manure	8	3	13
	100	100	100

The proportions are all given by weight. If we combine these percentage proportions with the chemical composition of each component already given, we get the following composition of refuse for summer, winter and for the average throughout the year:

TABLE 2.

	Summer. Per Cent.	Winter. Per Cent.	Average for Year. Per Cent.
Water	53	35	43
Volatile matter	13	11	11
Ash	20	35	30
Carbon	14	19	16
Total	100	100	100
B.t.u. per pound	2 850	3 350	3 120

If we reduce Table 2 to pounds per ton we get the following values:

TABLE 3.

	Summer. Pounds.	Winter. Pounds.	Average for Year. Pounds.
Water	1 060	700	860
Volatile matter	260	220	220
Ash	400	700	600
Carbon	280	380	320
	2 000	2 000	2 000

The successful bidder for the Milwaukee work based his guarantee on the chemical composition given in the following table. These percentages, as elsewhere, are given by weight of the wet material as collected.

TABLE 4.

	Summer. Per Cent.	Winter. Per Cent.	Average for Year. Per Cent.
Water	45.2	25.2	35.0
Volatile matter	18.2	12.7	18.7
Ash	26.8	41.5	30.6
Carbon	9.8	20.6	15.7
Total	100.0	100.0	100.0
B.t.u. per pound	3 134	3 900	3 475

Such, then, is the character of the refuse to be burned in the new incinerator. The quantity will be 300 tons per day. This will be made up of garbage from the whole city, and of the ashes and rubbish from wards 1 to 7 inclusive, together with sufficient manure to make up the total quantity. The quantity of small dead animals will not exceed one ton per day. The proportion of garbage in the refuse is, therefore, unusually high and does not represent the true average proportion for the whole city. Eventually, if other incinerators are built, so that all of the ashes and rubbish of the city, as well as all of the garbage, can be burned, the proportion of garbage will be lowered, and the calorific value of the refuse will be correspondingly increased.

Methods of Disposal.

There are several methods of refuse disposal, such as by dumping on the land or at sea, by burial in suitable soil, by feeding to swine, by reduction or by incineration.

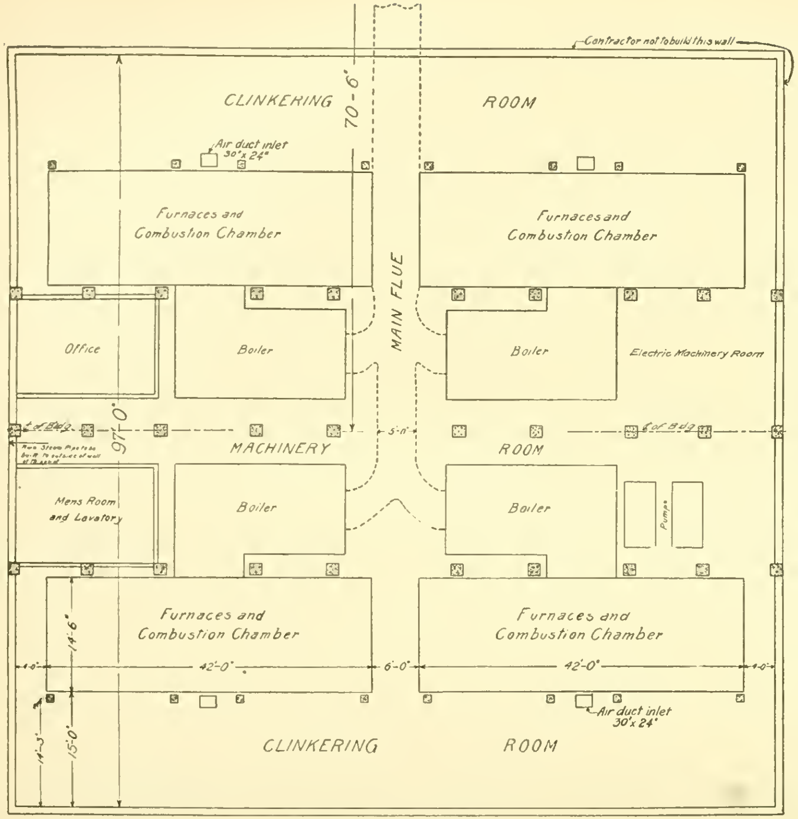
Ashes and rubbish are very often dumped on waste land within convenient hauling distance, as is done in your own city and in Chicago. This is dangerous to health, because germs of disease from sick rooms and hospitals may be lodged in the cast-off clothing and bedding, in the rubbish, and may be spread by the wind, by flies or otherwise. Such rubbish should be burned.

Dumping at sea or in the lake has been practiced in Milwaukee, but has never been favored as a permanent method of disposal. In New York City a portion of the garbage is dumped at sea.

Burial in the soil may satisfactorily dispose of garbage. Too often, however, the garbage is not buried, but is only spread out upon the ground surface to rot and create obnoxious odors. In York, Penn., such odors were objectionable at a distance of one mile.

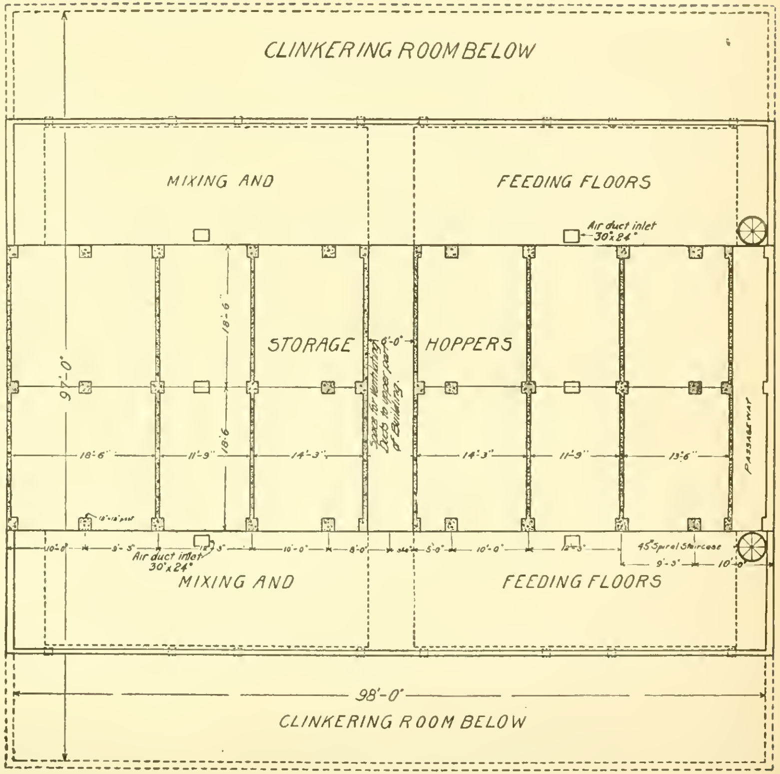
Feeding to swine is a method of disposal applicable to garbage only. It is used in Worcester, Mass., where about 3 000 pigs are kept to dispose of the garbage from a population of 130 000 people. The cost of disposal is about 85 cents per ton of garbage after deducting receipts from the sale of pigs.

The reduction process of disposal is also applicable to garbage only. It consists, briefly, in causing the garbage to be separated into three parts: water, grease and a dry material called tankage, which is useful as a base for commercial fertilizers.



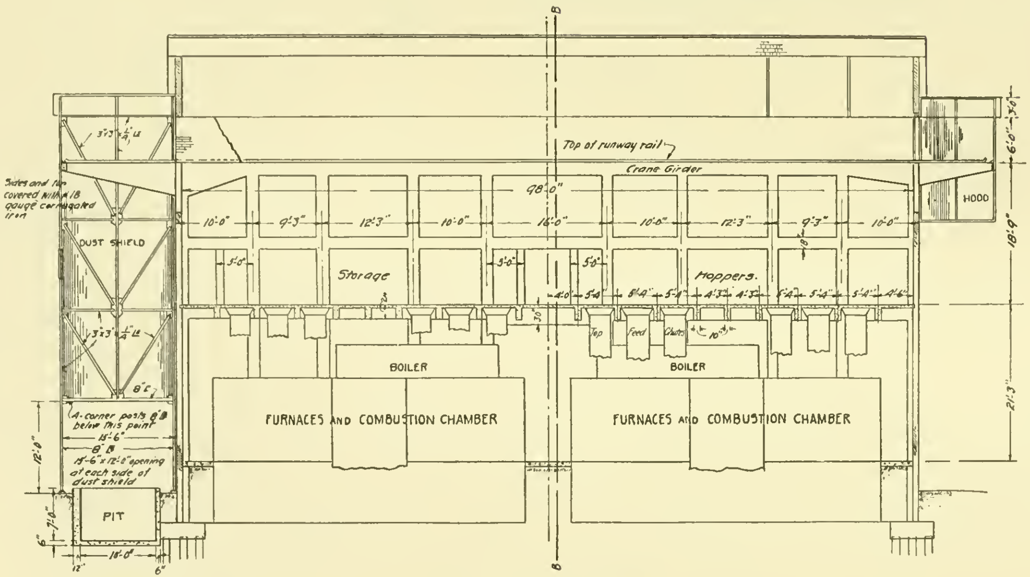
PLAN AT ELEVATION OF CLINKERING ROOM

FIG I.

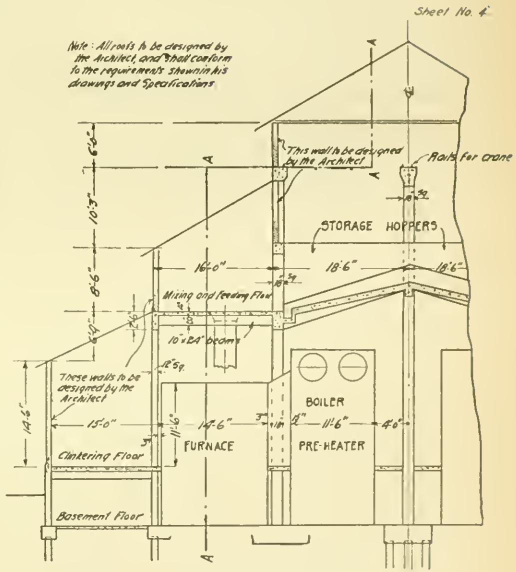


PLAN AT ELEVATION OF MIXING AND FEEDING FLOORS

FIG. 2.



SECTIONAL ELEVATION ON A-A



CROSS SECTION ON B-B

FIG. 3.

Incineration or burning of the mixed refuse of the city is the method of disposal recommended by Mr. Hering, and a refuse incineration plant is now under construction. There are two classes of plants designed to burn refuse. One of these is the natural outgrowth of the early American garbage crematory, which is designed to burn garbage only, and which requires the use of coal, oil or other auxiliary fuel. A plant of this kind is now in operation on Jones Island and burns the garbage of the city. Coal is the fuel used.

The other class of incinerator is based largely on experience abroad and is designed to burn mixed refuse. As distinguished from the refuse incinerator, the garbage crematory commonly burns garbage only, requires the use of an auxiliary fuel, operates at comparatively low temperatures and is not used to generate steam. Refuse incinerators, on the other hand, burn mixed refuse, use no additional fuel, operate at temperatures averaging 1500 degrees fahr. and generate useful steam.

These high-temperature refuse incinerators can be classified according to the method of charging. There are the bottom-charged incinerators, which are always charged by hand, and the top-charged incinerators, which may be charged by hand or mechanically. The bottom-charged incinerator is a front-fed or a back-fed incinerator depending upon whether the refuse is shoveled in through openings in the front wall or back wall of the furnace.

The Milwaukee Refuse Incineration Plant is a top-charged plant. It is also a mechanically-charged plant, because the refuse will be charged on to the grate through a mechanically operated device.

The Milwaukee Incinerator.

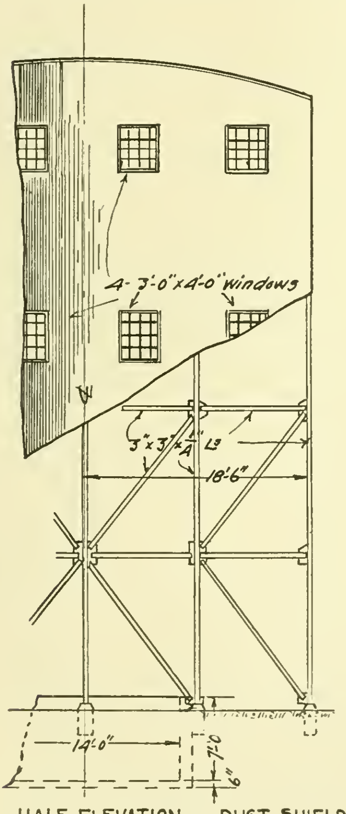
Figures 1, 2 and 3 show, in plan and sections, the plant designed for Milwaukee to burn the grades of refuse which have been described.

The building is about 100 ft. square and 45 ft. high to the eaves at the highest point, and the chimney is located west of the building, about 20 ft. from the wall. The plant comprises: (1) the two cranes and crane runways; (2) the storage hoppers; (3) the mixing and feeding floors with the mechanically controlled tubes for charging; (4) the floor for fans and fan engines; (5) the two clinkering floors on which the furnaces will front and between which will be the boilers, generators, office room and lavatory; (6) the basement, in which the clinker cars will operate and

which will make the settings of the furnaces and boilers accessible; (7) the main flue running east from the center line of the building; (8) the radial brick chimney; and (9) the recording and measuring instruments.

The foundations above the piles, the columns, floors, storage hoppers and crane runways will be built of reinforced concrete. The walls of the building will be of brick, and the roof of red reinforced cement tile.

The crane runways will extend out of the building over the roadways at the north and south ends of the plant. At the north end of the plant the garbage carts with their removable boxes will arrive. Bottom dumping rubbish, ash and manure wagons will deposit their contents into boxes placed in a special dumping pit at the south end of the building. The cranes, as they travel outside of the building, will be protected by galvanized iron hoods.



HALF ELEVATION OF DUST SHIELD
FIG. 4.

Three-ton, three-motor traveling cranes will be installed. They will lift the boxes from the garbage carts or from the dumping pits and will deliver their contents into the hoppers.

The storage hoppers will be built in four sections, one for each furnace, and each section will be divided into three compartments. Each section of three compartments will be about 36 ft. long over all and 17 ft. wide, with an average height of 7 ft. The floors of all the compartments have a slope of about 1 in 4 from a ridge along the center line of the building to the feeding and mixing floors at the foot of the slopes. At the bottom of each compartment will be a gutter covered by a perforated cast-iron plate and connected to the sewer. The hoppers are designed so that the ingredients of the refuse can be separately stored. In this way the free water in the garbage can drain away to the sewer.

Extending horizontally from the two hoppers, and separated by them, are the two mixing and feeding floors. The mechanically controlled charging tubes open at the level of these floors. there being six tubes for each furnace. The various ingredients of the refuse will be pulled down out of the hoppers and mixed properly on these floors, after which the mixed refuse will be pushed into the charging tubes.

The charging tubes will connect the feeding and mixing floors with the grates of the furnaces. They will enter the furnace through the top and will discharge on to a drying hearth at the back of the grate. In each tube, just above the furnace top, will be a door actuated by a wheel within the reach of the firemen on the clinkering floor. Turning this wheel lifts the door of the charging tube out of its sand-sealed seat and allows the contents of the tube to fall on to the hearth below. The tubes will be made of sheet steel and will be larger at the bottom than at the top. The doors will be made of plates and angles and will move on ratchet gears with an eccentric attachment to lift the door.

There are four furnace units, each of which consists of six grates or cells, a combustion chamber, an air heater and a water tube boiler. The six cells with the ducts at the back and with the combustion chamber will occupy a space 42 ft. 0 in. long by 14 ft. 6 in. wide and will be about 2 ft. high. The six cells are divided into two groups of three cells each by the common combustion chamber at the center. Each grate will have an area of about 20 sq. ft. At the back of each grate will be a drying hearth of brick. Back of this are two ducts — the hot-gas duct above and the hot-air duct below.

The hot-air duct will convey air, heated to a temperature of 300 degrees fahr., and under a pressure of about 4 in. of water, to the ash pits below the grates. This will be the air which supplies the oxygen for combustion. Fans driven by steam-engines will drive this air through an air heater placed in the second pass of each boiler below the tubes, and then through the hot-air duct and ash pit to the fuel on the grate.

The hot-gas duct will be directly over the hot-air duct and will convey gases from the combustion chamber along the duct, and through holes in the division wall between the duct and the drying hearth of each grate. These gases will be at a temperature of over 1000 degrees fahr. and will be driven by steam jets placed near the combustion chamber. These gases will absorb moisture from the fresh refuse standing on the drying hearth before it is raked on to the grates.

The furnaces will be built of brick masonry walls 18 in. to 24 in. thick, 9 in. of which will be fire brick. Special blocks will be used for the arches over the grates. The combustion chamber will extend down to the basement floor, 8 ft. below the ash pit.

The boilers will be of the horizontal water tube type, set high, with a tubular air heater set below the tubes in the second pass of each boiler. Each of the four boilers will have a rated capacity of 200 boiler h.p. The gases of combustion will pass from each group of three cells to the central combustion chamber, thence into the boilers and air heaters and, finally, through the flue into the chimney.

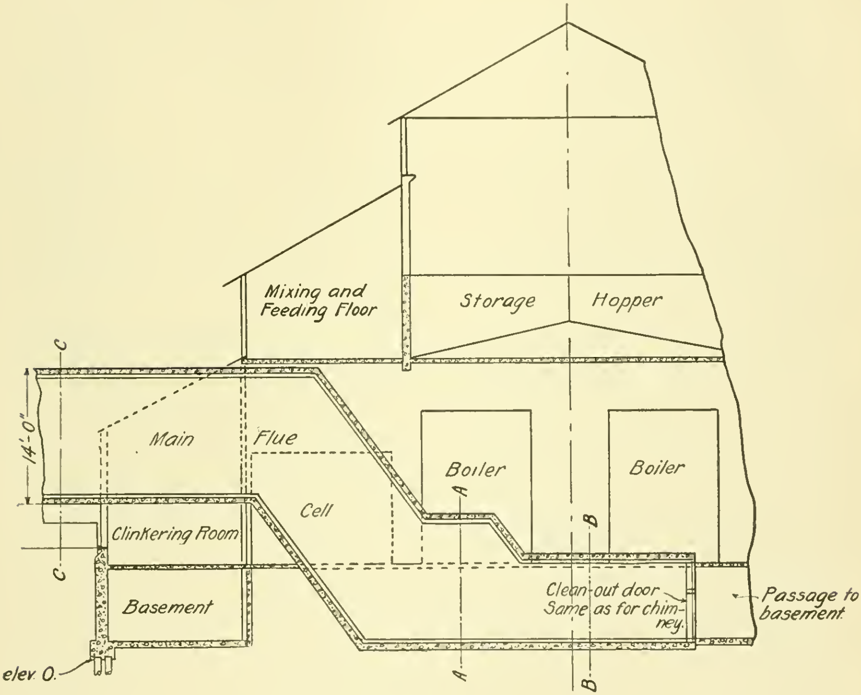


FIG. 5.

The fans and fan engines will stand on a floor raised about 5 ft. above the clinkering floor and located at the center of the building. There will be a fan and fan engine for each unit. Forty-eight inch Sirocco fans direct connected to 5-in. A, B, C vertical engines will be installed.

Clinkering will be done by firemen on the clinkering floor. As they draw the clinker from the grate, it will fall through a trap door directly in front of each grate and into a clinker car standing on rails below in the basement. This quickly removes

the dust and heat of the clinker from the firing room. Laborers in the basement will remove the clinker cars when necessary.

The basement extends under the whole building. All the boiler settings, the combustion chambers and the flue rest on foundations at the basement level and are provided with clean-out doors. In this way dust and soot can be readily removed.

The machinery is located at the level of the clinkering floor, between the furnaces and at the south end of the building. In the machinery room will be two 50 kw. 220-volt direct-current generating sets, two boiler feed pumps and a feed water heater. At the north end of the building will be the office room and a locker room for the workmen.

Instruments for measuring the temperatures and for analyzing the waste gases will be provided.

This design provides several special features to which I wish to call your attention as follows:

(1) The garbage, being stored by itself away from the ashes and rubbish, can be drained of its free water. According to analyses made by Prof. R. E. W. Sommer with Milwaukee garbage, this free water, which will drain away under pressure of the garbage itself, amounts to as much as 7 per cent. to 9 per cent. of the weight of the wet garbage. Draining this water away to the sewer reduces the amount of heat used unproductively to evaporate the moisture in the refuse, and the rate of evaporation in the boilers will be correspondingly increased.

(2) The drying hearth at the back of each grate, where the refuse is partially dried before it is raked on to the fire, increases the rate of combustion. The effectiveness of this drying hearth is increased by the hot-gas duct extending along the back of the hearth, which conducts the highly heated gases to the freshly charged refuse and reduces the percentage of moisture in the refuse before it is stoked on to the grate.

The drying hearth is also a valuable factor in increasing the life of the fire grate because it receives the impact of the refuse as it falls from the charging tube. Being of substantial brick construction, it is especially designed for this work.

(3) Storing the ingredients of the refuse separately in the different compartments of the hopper and providing a mixing floor as described will insure a uniformity in the grade of refuse fed to the fires. Where steam is generated, as in this plant, the value of this feature is evident. Furthermore, the grade of refuse can be somewhat adapted to the station load.

(4) The mechanical charging devices will make it unnecessary

to do any hand firing with wet, dirty refuse. This will reduce the manual handling of the refuse to as low a point as is possible without reducing the steaming results by removing all possibility of grading the refuse.

(5) Each operation in the conduct of the plant will be performed separately from every other. The cranesmen will work at top speed without interference from the men on the feeding and mixing floor. The men on the feeding and mixing floor will not be hindered by the men stoking the furnaces. Their whole work will be to keep the charging tubes full of refuse. Similarly, the firemen will work by themselves in a room which is free from objectionable refuse and hot clinker. Their whole work will be to keep the fires as hot as possible and to thoroughly burn all the refuse. Finally, the clinkermen in the basement will run the clinker cars out without interfering with the stoking above. These features should decrease the cost of operation.

(6) In burning refuse, a large amount of dust and soot is produced. If this dust settles on the boiler tubes it reduces the rate of evaporation and, if it goes up the chimney, it creates a nusiance. It is essential, therefore, to remove it. The arrangement of the grates on each side of a common combustion chamber causes the dust-laden gases to enter the combustion chamber from opposite directions. This will momentarily retard the velocity of the gases and cause the dust to settle out. The combustion chamber extends 8 ft. below the ash pit and forms a pocket for the detention of this dust. It is of large cross-sectional area, so that the velocity of the gases is somewhat reduced in this way. The boilers also are placed high, with their settings extending to the basement, and these settings, as well as the main flue, are all easily accessible for the removal of dust and soot and for repairs.

(7) Other features of special interest are the preheated air blast and the multicellular arrangement of the furnace grates. The air will be preheated to 300 degrees fahr. and will increase the temperature of combustion. The multicellular arrangement of the grates will keep the temperature uniform, with no decided low points in the temperature curve during clinkering.

Results.

The contractors for the Milwaukee work have guaranteed, under bond, to maintain an average temperature in the combustion chamber of 1500 degrees fahr., and to evaporate 1.1 lb.

of water from and at 212 degrees fahr. per pound of average annual refuse burned.

According to the analyses and calorific values of the refuse already given, these results should be obtained. That similar results have been obtained elsewhere in practice is well known. I will briefly mention one or two such instances.

In Seattle, Wash., there is a 67-ton bottom-charged refuse incinerator which has been in operation since January, 1908. Complete records of the operation of this plant have been kept and show satisfactory results. The temperature in the combustion chamber is almost always higher than 1250 degrees fahr., and the evaporation by actual measurement averages slightly more than 1 lb. of water per pound of refuse burned. The steam is used for the following purposes: (1) The operation of a 250 h.p. generator in parallel with the city lighting system; (2) the operation of a steam laundry; (3) the operation of a dry kiln in a kindling factory; and (4) the operation of a rock crusher with elevator and screens, which is used for the purpose of crushing and screening the clinker developed at the plant.

At Greenock, Scotland, there is a mechanically charged refuse incinerator which, for the twelve months ending January 31, 1909, developed an average of 67.2 kw.-hr. per ton of refuse burned. At this plant a temperature of from 1300 degrees to 2160 degrees fahr. is given as typical of a day's run. The electrical power generated netted about $8 000 for the year, and the clinker brought about $300. Several other plants which have been in successful operation for several years here and abroad might be mentioned. The indications are that the city of Milwaukee has made an excellent investment and, after many previous efforts, has now started out on the road which will satisfactorily solve the problem of the disposal of the city's refuse.

[NOTE. — Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by February 1, 1910, for publication in a subsequent number of the JOURNAL.]

CEMENT AND SAND FOR CONCRETE.

[An informal discussion before the Boston Society of Civil Engineers, May 12, 1909.]

MR. HERBERT L. SHERMAN.* — Testing cement is a rather broad subject to take up, but there are a few points that come up that are of interest to those of us who are doing a good deal of that work, and they may be interesting to you. We run across a great many difficulties in our line. A great deal of cement is tested, as you know, on the job. I do not wish, by any means, to decry the laboratory on the job; in fact, I think it is an admirable thing if properly conducted. But often, perhaps generally, this laboratory is not properly conducted. We find men testing cement on the job who leave the drafting table for a few minutes to make a few briquettes and then go back to the drafting table. Their business is not that of testing cement. Their business is drafting. It is simply a dirty job that they have got to do. That is the way they look at it, and it is unfortunate for all concerned that such men should test cement.

Another thing with which we have a good deal of difficulty is the matter of specifications. Specifications are submitted to us by engineers and architects which are only so-called specifications. Perhaps this is generally the fault of the architects rather than the engineers. I have a copy of specifications here which were recently submitted to me, and which I will read:

"All cement shall be tested under conditions and recommendations of the American Society for Testing Materials. Briquettes will be broken by a Fairbanks briquette testing machine. Cement shall not develop initial set in less than 30 min. and hard set in less than 8 hr. The average strength shall be at least 10 per cent. higher than the minimum. Minimum acceptable strength for briquettes 1 in. by 1 in. section follows:

"One day, 200 lb. Seven days, 550 lb. Twenty-eight days, 650 lb. The cement shall show no diminution in strength at any time. Fineness tests shall show at least 93 per cent. through 100 mesh sieve and 75 per cent. through 200 mesh."

Now, just note some of these recommendations. It says all cement shall be tested under conditions of the American Society

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for Testing Materials, and then goes on to say that cement shall not develop hard set in less than eight hours. The specifications of the American Society for Testing Materials are 10 hr. It says, further, that the average strength shall be at least 10 per cent. higher than the minimum. That is putting a premuim upon not making briquettes uniform. If I could make briquettes run all the same, — for example, if I could get three briquettes breaking at 600 lb. at seven days, — I should think that was wonderful work. But as a matter of fact, one may break at 570 lb. and another one at 620 lb. So this specification, calling for 10 per cent. higher than the minimum, is wrong in my estimation. Then, all they recommend is neat briquettes; it does not say neat briquettes here, but, of course, that is what it means. There is no sand test specified. Now the sand tests, as every engineer knows, are most important. And this seems a rather poor specification in that particular. Then it says the fineness tests shall show at least 93 per cent. through 100 mesh sieve. The standard test is 92 per cent. This starts out by specifying that the cement shall be tested under conditions and recommendations of the American Society for Testing Materials, and then changes them in almost every particular.

There is one thing, however, which I think is a good thing. They have specified the tensile strength tests at a certain definite figure. Now, the committee on drawing of specifications of the American Society for Testing Materials recommended, for example, that the tensile strength at 24 hr. neat should be a minimum of 150 to 200 lb. These specifications call for 200 lb. at 24 hr. It was the intention of the committee, in my opinion, that engineers should specify the strength that they wished to have. But it must be somewhere within those limits of 150 and 200 lb. In that, I think, these specifications are good, and in that only. And you can imagine how discouraging it is to those of us who are testing cement a good deal to get specifications like this and then attempt to pass on a sample of cement on its merits.

As I said before, the laboratory on the job is an admirable thing if properly conducted. But in my estimation it is not a good thing to have cement testing done by draftsmen. Another difficulty we run into is the temperature. Now, temperature is a very important consideration. The temperature of the laboratory must be kept as constant as possible, because there are very few things that will cause such variation in tensile strength, time of setting or any of the tests. I speak from

experience on this. A good many laboratories on the job are kept warm during the day, but, if it is winter, the heat is turned off at night, the storage tank freezes up and thaws out again in the morning, and the tests are of no value whatsoever, except possibly as showing the effect of alternate freezing and thawing.

Another test usually neglected on the job, and, in fact, in a good many testing laboratories, is that of normal consistency. I think one inexperienced in this line does not quite realize the value of that test. The standard specifications call for a test with the Vicat needle for determining this quality, and that is a very good thing, of course. But I have found in my experience a very simple test, and, perhaps, the old original test, is to make a ball of cement and drop this from the height of a foot on to your mixing board, and if it doesn't materially flatten out or crack the consistency is right. The Vicat needle test is perhaps better, but there is very little difference in result, and the ball test is better for the reason that it does not require so much cement and it is much quicker. The fact that it does not require so much cement is important, as we find, because we very often have samples sent us in small paper bags, with the request that we make all tests. Of course there may be enough there to make a pat and two or three briquettes, and we are expected to give a complete report on that. Of course, such a thing is impossible. But if we make our normal consistency test in that way and happen to strike it right, we can use the ball that we used in the normal consistency test for a pat and so save that much. But if any of you are sending in cement to a testing laboratory, do not send too little. Send five or six pounds. Do not be afraid of sending too much. The effect of that normal consistency test is quite important. I know of a laboratory quite near here where the method is to use 20 per cent. of water with all neat tests. Now that is a rather queer rule. Most cements when mixed in 20 per cent. water are extremely dry, and in this laboratory the briquettes are hammered into the molds with a mallet. Is it strange that they should get a tensile strength of 800 lb. neat in seven days and practically no increase in twenty-eight days? And still this remarkable strength in seven days is sometimes held up as a fine thing.

Another thing I wish to speak of particularly is the effect of alumina on cement. Some time ago the Aberthaw Construction Company approached me and asked me if I would be willing to make tests with them on the piers they wished to build at the Charlestown Navy Yard, to determine the effect of sea water.

This has always been a pet subject of mine, and I was anxious to use cements containing different percentages of alumina. So we used, among others, a cement containing a low percentage of alumina, a cement containing a high percentage, a cement which we considered a normal American Portland cement, a cement with no oxide of iron and a cement with no alumina. Professor Le Chatelier a good many years ago established the fact by laboratory tests that alumina of a high percentage was dangerous for this reason, that the sulphate in the waters acts on the aluminate of lime to form sulpho-aluminate of lime, which is an expansive. The percentage of alumina which is dangerous he did not establish, so at present we do not know. But we do know this, that the lower the percentage of alumina the better, provided we can still maintain all of the properties of true Portland cement. All of the tests to date we have made on the cement for the navy yard piers have been normal, except in the case of iron ore cement. This is made in Germany, and is now, I understand, made commercially. The alumina is entirely replaced by oxide of iron. According to the laboratory tests, this should prove ideal for work in salt water, the sulphates in the sea water not having any alumina, of course, to act upon. I have made some tests on this iron ore cement and here are my results:

	Per Cent.
Loss of ignition	0.91
Silica	24.28
Alumina	0.94
Oxide of iron	9.08
Lime	62.12
Magnesia	0.43
Sulphuric anhydride	1.75

Note that the oxide of iron, 9 per cent., replaces all of the alumina practically. Then the physical tests on that give:

Initial set	45 min.
Final set	26 hr.
Fineness, No. 100 sieve	95.8 per cent.
Fineness, No. 200 sieve	82.6 per cent.
Accelerated tests, boiling and steam	Satisfactory.
Specific gravity	3.267.
Tensile strength, 24 hr. neat	Not hard set.
Tensile strength, 48 hr. neat	223 lb. per sq. in.
Tensile strength, 7 days neat	441 lb. per sq. in.
Tensile strength, 28 days neat	641 lb. per sq. in.
Tensile strength, 3 months neat	796 lb. per sq. in.
Tensile strength, 7 days, 1–3	132 lb. per sq. in.
Tensile strength, 28 days, 1–3	234 lb. per sq. in.
Tensile strength, 3 months, 1–3	327 lb. per sq. in.

That is as far as we have conducted the tests at present. Note the time of setting. The aluminates in cement are responsible mainly for the setting properties, and that is shown here very well with that extremely long setting time. Of course it is impossible at the present time, or almost impossible, to use that cement commercially. That setting time is too long for many of us to wait. We cannot wait over twenty-four hours for the concrete to set. And so I think that, perhaps, commercially, this will never prove a success with such a small amount of alumina. I think that a cement could be made which might contain, say, 2 per cent. of alumina, or possibly 3 per cent., which would give enough alumina to cause it to set properly and then would still have the effect of being proof against the action of the sulphates in the sea water by reason of the small amount of alumina. Of course, this is entirely supposition on my part, but I do not think really that that amount of alumina would be dangerous. I think that is all I have to say.

Impurities in Sand for Concrete.*

Mr. Sanford E. Thompson. — During the last two or three years attention has been called to several cases where concrete failed to harden which could not be traced to the quality of the cement. Some of these failures have been quite thoroughly investigated. One in particular was investigated to a point where quite definite conclusions were reached, and will serve as an illustration of at least one of the causes of poor concrete.

It has been proved conclusively that the sizes and the gradations of sizes of particles of sand affect the density, strength and permeability of the mortar, and definite laws governing these relations have been framed, notably by Mr. Feret † in France, which show that with sand having grains of known sizes the strength of the mortar may be estimated. These laws have been corroborated in a general way by tests in the United States and elsewhere.

In this country also further tests have shown the effect of scientific methods of proportioning or grading the aggregates of the concrete upon its density and strength.‡

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* This discussion was also presented to the American Society of Civil Engineers at its annual convention, July 8, 1909, and the original imprint appears under this title in the Proceedings of that society for September, 1909, page 973.

† *Annales des Ponts et Chaussées*, IV, 1892.

‡ See "Laws of Proportioning Concrete," by William B. Fuller and Sanford E. Thompson, Trans. Am. Soc. C. E., Vol. LIX, p. 67.

However, every little while one runs across a sand which absolutely fails to obey the laws of gradation of sizes or of density. Not only may the mortar or concrete made from such sand fail to show the strength which would be expected, but it actually fails to harden, or hardening which should take place inside of a week is delayed for perhaps two or three months.

Frequently the sand which produces such bad results looks all right, and those who have had much experience in concrete construction are deceived by the appearance. The mechanical analysis of the sand, that is, the gradation of sizes, may be good, and it may appear clean, and yet the quality may be such that it has to be absolutely prohibited from use in concrete, while if used without previous testing it will cause failure.

This does not disprove the laws referred to. It simply indicates that there is something further, that the laws of density apply to a clean sand, and that frequently there is some other material in the sand which affects the combination of the sand and cement either mechanically or chemically, or perhaps both. Such results, such failures of the mortar and concrete to set, show the absolute necessity, not merely of a careful examination of a sand which is to be used, not merely of a mechanical analysis to determine the sizes of the particles, but of a laboratory test, as thorough a test, in fact, as would be given to the cement itself.

In the special case referred to, a two-story machine shop with concrete walls was being erected by a local contractor with no engineering advice except in the preparation of outline plans. The walls of the basement were 12 in. thick, of the first story 10 in. thick, and of the second story, 8 in. The interior of the building was mill construction with timber beams and plank floors. One night when the walls were just above the level of the second floor, during a severe wind storm, the building collapsed. An examination by the speaker, who was called upon to make an investigation immediately after the accident, showed that the concrete, although mixed in proportions 1 : $2\frac{1}{2}$: 5, had failed to harden even in the basement.

The concrete of the entire building was so soft that although parts of it had been laid for at least two months, a knife blade could be thrust into it, and it was even difficult to pick from the wall a piece of concrete hard enough to carry away as a sample.

The appearance of the concrete was dark and dirty. There was a thin, hard skin on the outside which had helped to deceive the contractors into believing that the material would eventually harden, although they were by no means satisfied with it.

Investigation showed that the concrete had been proportioned 1 : 2½ : 5 and mixed in a satisfactory manner. It was hand mixed, but apparently well done, and tests of the actual proportions by analysis of the concrete were considered unnecessary.

It was evident that the cause of the trouble lay in the materials. The last of the carload of cement had been used, only the empty bags remaining, and because representative samples of this cement could not be obtained, it was necessary to test the rest of the materials much more carefully than otherwise would have been necessary.

The sand and gravel were taken from the site of the building when excavating the cellar. The gravel was ordinary New England gravel, ranging from fine, that is, ¼ in. particles, up to perhaps 2 in. in diameter. It was fairly clean. Some of the pieces were slightly coated with dirt, but no more so than is almost always found in a gravel bank.

The gravel screened contained about 12 per cent. of sand finer than ¼ in. size; that is, the screening was imperfect. However, this is almost always the case with screened gravel, so that in gravel concrete there is apt to be an excess of sand over the nominal proportions specified. In screening, a part of the sand, especially on wet days, is carried down with the larger stones.

The gravel was washed, as gravel is usually washed in hand-mixed concrete. A hose was turned on to the pile before the mixing was begun, and the fine material was washed down to the bottom of the pile and shoveled into a wheelbarrow with the rest. Then the gravel from the barrow was dumped on to the mixing platform, and again it was washed with the hose, the dirt simply flowing with the water from the surface to the bottom of the pile to be shoveled up and mixed with the gravel in the concrete. This is the ordinary but ineffective way of washing gravel in hand mixing, unless special apparatus for washing is employed.

The sand appeared good. In some places it was rather dark colored, but most of it would pass an ordinary inspection and would be called a sand of fairly good quality, certainly good enough for the work which was being done. The results of the mechanical analysis of the sand, which are given in an appendix, were above the average. Three per cent. by weight passed a No. 100 sieve, and about 25 per cent. was caught on a No. 8 sieve, but a closer examination of the bank showed considerable

variation in the sand; in some places it was rather dark and reddish in color, while piles where it had dried out looked "dead."

A practical test was suggested by the representative of the cement company, which had never before come to the attention of the speaker. Taking a double handful of moist sand from the pile, he allowed the sand to run through between his hands as they were held with the thumbs up about 1 in. apart, at the same time moving his hands back and forth. Repeating this operation several times, always taking naturally moist sand from the interior of the bank between the fingers of both hands, there was collected a dark slimy substance which contained scarcely any grit. Some of this scraped from the fingers and afterwards tested by ignition was found to consist almost entirely of vegetable matter.

A further examination of the bank showed that in places where it had been cut to a vertical face for an excavation or for screening out the sand, the rain had washed down from the surface soil a material similar to that which had collected between the fingers on the above test, which formed a scum on the vertical face of the bank.

The surface soil was ordinary medium quality of loam with, however, one or two dark, almost black, streaks in it, about half to three quarters of an inch thick.

All the indications seemed to point to the cause of the trouble being vegetable matter in the sand, and vegetable matter which had apparently been washed down by the rains from the surface soil into the porous sand and gravel underneath, gradually coating the grains.

Tests of Sand. — Samples were taken of the sand and stone and subjected to thorough tests. The mechanical analysis has been referred to and is shown in full in Table 1.

Very fortunately for purposes of comparison, the speaker happened to have in his laboratory a large sample of another sand which had been used satisfactorily in the construction of a reservoir * near Boston, which, because of its size and shape, 100 ft. in diameter and nearly 50 ft. high, required special tests of its materials. The mechanical analysis of this good reservoir sand (shown in Table 1) was found to be almost identical with the sand used in the building which failed; moreover, the chemical composition was also practically identical, each containing about 75 per cent. quartz.

* See *Engineering Record*, January 12, 1907, p. 32.

TABLE 1. — MECHANICAL ANALYSIS.

Analysis No.		A-92.			A-96.		
Description		Average Sand from Excavation.			Reservoir Sand.		
Date of collection		May 5, 1908.			1907.		
,, ,, analysis		May 8, 1908.			May 9, 1908.		
Percentage of Moisture		2.6 before drying.			0		
Size of Sieve.		Total Weight Passing.	Total Percentage Passing.	Percentage Passing ¼-in. Sieve.	Total Weight Passing.	Total Percentage Passing.	Percentage Passing ¼-in. Sieve.
Inches.	No.						
1.50	1½ in.	97.0	100.0	100.0	100.0	100.0	100.0
1.00	1 in.	97.0	100.0	100.0	100.0	100.0	100.0
0.50	½ in.	97.0	100.0	100.0	100.0	100.0	100.0
0.25	¼ in.	92.7	95.6	100.0	96.2	96.2	100.0
0.16	5 in.	81.8	84.4	88.4	88.9	88.9	92.5
0.0583	12 in.	56.5	58.2	61.0	68.2	68.2	71.0
0.0335	20 in.	39.5	40.7	42.6	48.2	48.2	50.1
0.0148	40 in.	14.6	15.0	15.8	17.0	17.0	17.7
0.0055	100 in.	2.6	2.7	2.8	2.3	2.3	2.4
0.0030	200 in.	1.8	1.9	2.0	1.1	1.1	1.1

Notwithstanding this apparent similarity, 1 : 3 mortar from the reservoir sand gave a strength of 272 lb. in 7 days and 332 lb. in 28 days, while the poorest sample of the sand in question gave an average of 20 lb. in 7 days and 75 lb. in 28 days.

Volumetric Test. — To be sure that the bad quality of the sand was not due to the shape of the grains, which might prevent proper compacting and consequently an excess of voids in the mortar, volumetric tests were made and the density was found to be normal. The density of 1 : 3 mortar made with the sand in question was 0.679, and that of mortar made from the reservoir sand in the same proportion was 0.683.

Mica. — A little mica was observable in the samples: A careful examination, however, indicated that this was not sufficient to cause trouble.

Clay. — It has been sometimes claimed that clay matter is injurious to sand from a chemical standpoint. An examination of the chemical analysis shows, however, that the amount of clay, although large, was approximately the same as in the good reservoir sand, and, therefore, cannot be considered as the cause of the poor quality.

Tensile Tests. — The tensile strength of the mortar from the sand in question, as already stated, averaged 20 lb. per sq. in. in 7 days and 75 lb. in 28 days.

The tests in different series using sand from different parts

of the bank ranged in the 7-day test from 11 to 40 lb. To be sure that the cement used in testing or that the laboratory methods were not at fault, tests were made in two different laboratories and with three different cements. Three different proportions were also used, namely 1 : $2\frac{1}{2}$, 1 : 3 and 1 : $3\frac{1}{2}$. Specimens were stored for comparative tests in air, in moist closet and in water. The results all checked so closely as to eliminate the question of cement or of manipulation.

Comparison of Moist and Dry Sand. — A comparison of 1 : 3 mortar made with the moist sand as it came from the natural bank and from the same sand after drying showed some relative increase in strength due to the drying. In this series the average strength at 7 days of the sand direct from the bank was 8 lb., and of the dried sand mortar, 23 lb.

Comparison of Natural Sand and the Same Sand after Washing. — A comparison of the sand in question before and after washing is as follows:

Unwashed sand, 40 lb. at 7 days; 102 lb. at 28 days.
Washed sand, 97 lb. at 7 days; 196 lb. at 28 days.
Standard sand, 200 lb. at 7 days; 275 lb. at 28 days.

The grains of the washed sand were not thoroughly clean.

Microscopical Examination. — The microscopical examination of the grains of sand as obtained from the bank showed them to be covered with a dark brown coating which did not readily brush or wash off. The particles of the Waltham sand, on the other hand, were clean. A strong magnifying glass was found efficient in examining the grains for coating.

Washing Tests. — To examine and test the character of the silt in the sand it was found necessary to remove the fine matter by washing.

To compare the results by washing and by screening out the silt through a No. 100 sieve, tests were made in both ways with the following results:

Worst sample of defective sand: 1.60 per cent. silt by washing; 1.14 per cent. by screening.

Average sample of defective sand: 2.46 per cent. silt by washing; 2.68 per cent. silt by screening.

Good Reservoir sand: 1.16 per cent. silt by washing; 3.66 per cent. by screening.

Although there is but slight difference between the results from washing and from screening, the chemical analyses indicate that the washing removes much more of the deleterious vegetable

matter than the screening, so that this process should be followed when testing silt in sand.

It is noticeable in the above results that the poor sand gave a larger per cent. of silt by washing than by screening, while the good sand gave a much smaller per cent. by washing, indicating that in the latter case a large proportion of the very fine material was of heavier mineral origin.

The method used in washing to remove the silt was a very simple one, but was found more effective than several other more elaborate methods that were tried. The sand was placed in a large-mouthed quart bottle about half full of water and shaken thoroughly. The dirty water was poured off and the operation repeated several times until the water was nearly clear. The wash water was then evaporated, the residue thoroughly dried, and the loss on ignition, which determined the quantity of organic matter, was found.

Before igniting, the silt was passed through a No. 100 sieve to remove large particles of dirt which evidently would not be injurious if distributed through the mortar.

Chemical Analysis of Silt. — Both the poor sand in question and the good reservoir sand were washed and a chemical analysis made of the silt, including a test of the residue by ignition. The analyses of the silt were as shown in Table 2:

TABLE 2.
ANALYSES OF SILT.

	Reservoir Sand. Per Cent.	Average Sand B from Silt. Per Cent.	Worst Sand G from Silt. Per Cent.
Moisture	7.80	8.24	13.07
Silica	54.12	45.32	34.94
Alumina	23.10	25.13	20.80
Oxide of iron	9.00	6.71	5.90
Lime	2.07	1.93	
Organic matter	2.50	11.86	26.33
Approximate percentage of clay	45	50	35

Inspection of these analyses shows but one notable difference: The organic matter in the silt from the reservoir sand was 2.50 per cent., while in the silt from the poor sand it was very high. In one of the samples of poor sand the organic matter was 11.9 per cent., and in the other, 26.3 per cent. When ignited, the organic matter in the poor sands gave off a peculiar odor of woody fiber, or leaf mold, thus indicating its probable vegetable origin. The good reservoir sand, on the other hand, gave no

appreciable odor and showed a reasonably small percentage of organic matter.

Reference is made above to the comparison of screening and washing. Tests by ignition show that frequently double the percentage of organic matter is obtained by washing that is obtained by simply screening.

It is noticeable that the silica is low, but in this connection it must be remembered that this is the analysis of the silt and not of the total sand.

Introducing Silt into Standard Mortar. — To still further confirm the conclusion that the silt was the cause of the trouble, a mortar was made up of 1 : 3 standard sand with an addition of $1\frac{1}{2}$ per cent. of silt based on the weight of the sand. The resulting tensile strength of the mortar was 29 lb. per sq. in. in 7 days and 107 lb. in 28 days, whereas the normal strength of the standard sand mortar was about 200 lb. in 7 days and 275 lb. in 28 days.

A similar test was made by introducing 1.5 per cent. of silt into neat cement and the resulting strength was about one half that of the neat cement without silt.

Concrete Tests.— Specimens of concrete were also made, using sand from different parts of the bank in different tests. The cement used in these tests was of a well-known brand, which was carefully tested to see if it was normal. The poor sand and gravel from the site of the building were used in the test as well as the good reservoir sand and gravel. The blocks were broken at the age of about 18 days at the Watertown arsenal, with the results shown in Table 3.

TABLE 3.

COMPRESSIVE STRENGTH OF CONCRETE IN POUNDS PER SQUARE INCH. AGE, 18 DAYS. PROPORTIONS, $1 : 2\frac{1}{2} : 5$.

	Cement H.		Cement A.	
Aggregate.	Individual.	Average.	Individual.	Average.
Sand A and Gravel E,			200	200*
Sand $\frac{1}{4}$A + $\frac{3}{4}$B and Gravel E,	818 692	755	625 749	687
Sand W and Gravel E,			653+	
Sand W and Gravel W,			1 505	1 505†

NOTE. — Sand A. Worst sand from site of building.
Sand B. Average sand from site of building.
Sand W. Good reservoir sand.
Gravel E. Screened gravel from site of building.
Gravel W. Screened reservoir gravel.
* Only one specimen, but a good specimen.
† Only one specimen, and possibly slightly defective.

Hardening of Specimens. — Careful watch was kept of the specimens of concrete and of mortar as they hardened, and pats of the concrete were also made. The mortar and concrete made with the good reservoir sand set up hard within 24 hr. with a light gray color, while the other specimens remained so soft that they could not bear the pressure of the thumb nail for several days.

Conclusions. — As already stated, the tests indicated conclusively that the trouble with the sand was due to the vegetable matter which it contained. Subsequent tests of other sand and examination of structures indicate this to be a common cause for poor mortar or concrete. In many cases no failure results, but the concrete does not harden properly and never becomes as strong as it should.

The percentage of silt given in the chemical analysis of the silt appears large, in one sample being 11.9 per cent. and in another 26.3 per cent. However, when given in terms of the total sand it is a very small percentage because there is so small an amount of silt in the sand. Based on the weight of the total sand before washing, therefore, the percentage of silt as it comes from the bank is 0.27 per cent. in one case and 0.39 per cent. in another case, an extremely small amount, and one which would not show up by any test of settlement in water or rubbing in the palm of the hand.

These and other tests indicate that there are two percentages of vegetable matter which appreciably affect the quality of a sand. First, the percentage of vegetable matter in the silt, and, second, the percentage of vegetable matter in the sand. Although the tests thus far made are too few to draw definite quantitative conclusions, it would appear that, in order to be injurious, the percentage of organic matter in the silt must be more than 10 per cent. and at the same time the percentage of organic matter in the total sand must be more than $\frac{1}{10}$ of 1 per cent.

Both of these conditions are necessary because it appears from tests that in certain cases the percentage of vegetable matter in the silt may be above 10 per cent., but there may be so little silt in the sand that the percentage of organic matter in the total sand will be less than $\frac{1}{10}$ of 1 per cent., and the sand will pass the tensile test.

Whether the cause of the results is due entirely to chemical action or whether it may be due in part to mechanical action, the organic matter surrounding the grains so that the cement will

not adhere, has not been determined. Most probably the cause is chiefly chemical, but in a small measure also mechanical. The subject appears to be of sufficient importance to warrant thorough further investigations.

In conclusion, special stress should be placed upon the necessity in concrete work of thorough tests of the sand. It is not merely necessary to examine sand with the eye; it is not sufficient to test it by rubbing it in the hands; it is not enough to make a mechanical analysis and to determine the sizes and the gradations of the particles, but in every case, unless the sand is from a bank of known good quality and has been previously tested, as careful tests should be made as are required of the cement. Probably the best test is the ordinary tensile test required by the Joint Committee on Concrete and Reinforced Concrete which requires that "mortars composed of one part Portland cement and three parts fine aggregate by weight when made into briquettes should show a tensile strength of at least 70 per cent. of the strength of 1 : 3 mortar of the same consistency made with the same cement and standard Ottawa sand."

In case a sand must be used immediately, with no time to make tensile tests, or in case special investigations are needed to determine the causes of poor quality, the washing test and determination of the organic matter is of special value. The mechanical analysis, which shows the proportions of the grains of different size, is also of great value as indicating the comparative value of different sands which are free from organic matter.

Mr. J. R. Worcester. — Mr. Sherman spoke about the specifications of the Society for Testing Materials, and it seems to me that it would do no harm to emphasize a little more than he did one clause which needs further elucidation by the engineer in making his specification. In making specifications for cement, if you say it shall be in accordance with the specifications of the Society for Testing Materials, it is not quite sufficient. As you all know, the clause covering the tensile tests of briquettes has limits — 150 to 200 and so on. Those limits have almost invariably been misunderstood, in spite of the footnotes and the precautionary clause added by the committee. I was quite astonished a few days ago to be told by one of the dealers in cement here in Boston — a man who sells a great quantity — that he never had heard of any other interpretation of that specification than that cement that came within the limits was all right. I asked him how about the upper limit, — whether he would reject cement that went above the upper limit. No, he wouldn't

exactly do that. The amount of it was that he thought anything that went above the lower limit was safe. The intention of the committee was that the engineer in making his specifications should say what his minimum tensile strength should be and should specify a limit somewhere between those given. It is useless to say that the cement shall be in accordance with the specifications of the Society for Testing Materials, and then go on and give a long list of requirements which do not correspond with the specifications of the society, as did the man who wrote the specifications read by Mr. Sherman. It is necessary only to say that the cement shall correspond with the standard of the Society for Testing Materials and that the tensile strength shall be so much at various periods.*

I have a little to say along the same line followed by Mr. Thompson, and possibly I shall repeat a little of what he has said with regard to sand. But it may be well to emphasize his points. We have all, I think, experienced difficulty in determining what is good sand and what is not good sand. I know that in a great many instances I have been asked to pass an opinion upon a sample of sand, and not until comparatively recently have I had any idea how to do it. I think we all have tried washing it — that is, putting water on to it to see how much the water is discolored. But Mr. Thompson's experience has clearly proved that that is not all that is necessary. The granulometric analysis of sand has been advocated by some, but I have yet to learn of any specification for a granulometric analysis that will inevitably discriminate between a good and a bad sand. It may be helpful, but until we know more about just what compositions it is safe to pass and what not to pass, it does not settle the point very satisfactorily.

The recommendation made by the joint committee on concrete and reinforced concrete that sand to be used on the job shall be tested in mortar briquettes along with the cement, to see what tensile strength will be developed in a seven-day period and how that strength compares with the tensile strength of mortar made from standard sand, seems to me to be the most satisfactory requirement that has so far been devised. We have had occasion this past winter to pass upon many kinds of sand from different places, and we had in the specification adopted that rule of the joint committee that the sample should develop

* Since this explanation was made, the Society for Testing Materials has revised the specifications and the uncertainty referred to no longer exists.— J. R. W.

70 per cent. of what the same cement would develop with standard sand. Possibly you may be interested to know the result of the work we did along that line and how satisfactory it proved.

I might say right here that in Boston sand is one of the hardest things to obtain. We have no trouble in getting cement. We can get any quantity of that, and good cement, but sand is not so easy to obtain here in Boston; and a great deal of what is being used and what had been used in the past is mighty poor. Some of it which looks all right and which will wash all right — and I believe will pass a fair granulometric test — will make a mortar or concrete which oftentimes is condemned because it is poor concrete, and it isn't the fault of the cement either. I won't weary you with the detailed figures of the tensile results, but I will read the percentage of strength that the sand which was being tested developed of the standard sand briquettes at 7 days and 28 days, the results generally being based upon an average of six briquettes for each period. We had fifteen different kinds of sand which we tested.

The first one at 7 days developed 66 per cent. of the standard, and at 28 days, 59 per cent.

The second at 7 days developed 67 per cent. of the standard, and at 28 days, 60 per cent.

The third at 7 days, 83 per cent.; at 28 days, 92 per cent.

The fourth at 7 days, 95 per cent.; at 28 days, 109 per cent.

That was a constant improvement, as the contractor discovered that we were testing. The order is chronological. Then we had a break.

The fifth at 7 days gave 48 per cent.; at 28 days, 57 per cent.

The sixth at 7 days, 88 per cent.; not tested at 28 days.

The seventh at 7 days, 57 per cent.; at 28 days, 57 per cent.

The eighth at 7 days, 133 per cent.; at 28, 132 per cent.

The ninth at 7 days, 107 per cent.; at 28, 85 per cent.

The tenth at 7 days, 73 per cent.; not tested at later period.

The eleventh at 7 days, 107 per cent.; at 28, 89 per cent.

The twelfth at 7 days, 57 per cent.; at 28 days, 57 per cent.

The thirteenth at 7 days, 76 per cent.; at 28 days, 75 per cent.

The fourteenth at 7 days, 96 per cent.; at 28 days, 70 per cent.

The fifteenth at 7 days, 116 per cent.; not tested at later period.

To summarize these results, we found that out of 15 samples of sand tested, 5 failed to meet the requirements and were re-

jected; 5 proved better than the standard sand, and 5 fell between the limits of 73 per cent. and 92 per cent. of the standard. That is, two thirds were accepted and one third rejected. We also noticed one or two other things. Those that failed at 7 days maintained just about the same percentage of the standard at the 28-day period. I will say that the determination was made at 7 days, and the 28-day tests were made as a sort of check to see whether it was safe to work by what we could obtain at the 7-day period. None that were rejected on the 7-day test would have been accepted if they had been judged by the 28-day period, because the percentage did not go above the limit. On the other hand, none accepted on the 7-day test would have been rejected if they had been subjected to the 28-day test. These results, of course, are not conclusive, and we have got to learn by further experience; but so far as we have gone we find the method very satisfactory as a criterion for determining what the sand is good for. I would say that the process does not generally delay the work. Of course it requires the contractor to get the sand in quantity enough so that he need not use it for seven days, the same as he does his cement, and the time he is waiting for sand is only the time he is waiting for his cement tests. Moreover, it gives you something definite in your specification, and oftentimes the specification is valuable only in so far as it assists the engineer to make a positive decision. An engineer in looking after work is often handicapped by a clause that is dependent on judgment and susceptible of argument. This is a requirement that you can determine absolutely and will greatly fortify you in condemning an inferior material.

Mr. E. S. Larned. — The topics under discussion this evening are of unusual interest to me and have commanded my almost undivided attention for a number of years past.

I rejoice to see engineers more generally recognizing the necessity of carefully testing sand before use in mortar or concrete work, and hope that the importance of so doing will cease to be a subject for discussion with architects and engineers generally by reason of its universally acknowledged importance.

The American Society for Testing Materials has taken a long step in advance in proposing a specification and test requirement for sand, requiring that it show at least 75 per cent. of the strength developed by the Standard Ottawa Sand in laboratory tests. This is not a difficult requirement to meet, since a fairly good clean bank sand, moderately coarse and fairly well graded, will show results superior to the Ottawa sand, which is artifi-

cially prepared to comparatively uniform size for the purpose of securing uniform results in testing cement for purposes of comparison.

Much has been said and written about the advantages and disadvantages of clay and loam in sand, and some experimenters report better results by adding given percentages of clay and loam to sand than in testing the sand without the addition of this foreign material. Opinions based upon the results of such laboratory experiments as above noted have been the cause of wretched results and sometimes actual failures in practical operations, and I think should be avoided without exception.

Conditions may be found where a sand entirely free from clay or loam cannot be procured except at almost prohibitive cost. In such cases, careful and thorough laboratory tests should be made of the material, and the required strength of mortar fixed, if possible, by the addition of cement.

In considering the meaning of tests where clay has been added in different percentages to the sand, we must take into account both the character and size of the sand grains, the proportion used and the amount of water used; also the method of keeping the briquettes either in air or water between the time of making and the application of the test load.

While some experimenters have found that in certain sands they can use considerable additions of clay with good results, their determinations cannot be taken literally as applying to practical conditions.

It is a well-known fact that clay, fine, dead sand, even though siliceous, and other foreign materials, seriously retard the hardening of cement mortars and consequently would likewise affect concrete.

If the sand be perfectly dry, as in the case of laboratory tests, and the clay also dry and finely pulverized, you can see that a more intimate and even mixture can be obtained than in the case where the sand may be moist and the clay occurs in lumps. The results are also affected by the degree of mixing and manipulation, which in the laboratory is carried to a greater refinement then it ever reaches in practical operations.

If a moderately coarse sand be used, and the proportion of cement added is not quite sufficient to fill the voids in the sand, it is conceivable that a small addition of clay, sufficient in addition to the cement to completely fill the sand voids, would result in a denser mixture and consequently increase the compressive strength of the mortar. This result is contingent, however,

upon the sand and clay being dry when first mixed and the cement thoroughly and uniformly distributed through the fine aggregate.

Where clay is found in association with sand in a bank, it becomes a question of how the clay is contained, i. e., whether in the nature of silt uniformly distributed throughout the sand or in layers or strata of small or considerable depth. If it occurs in the latter form, it naturally follows that it will be in the form of lumps throughout the sand, and ordinary mixing is not sufficient to break this up and distribute it uniformly throughout the sand voids, and, in consequence, weak spots will be found in the mortar or concrete made from such materials.

If the sand grains and fine gravel be coated with clay, as is often the case, it will require a comparatively wet mixture and vigorous working to dissolve the clay sufficiently to enable the cement to bond with the sand and gravel surfaces, and even then results are more or less uncertain.

The presence of clay depends upon its physical condition, or its state of division, whether in such condition that the individual atoms can mingle with the mechanical mixture as a filler, or whether it is in a colloidal, or state of semi-solution (gelatinous), such that it reacts on the total mixture so as to prevent the bonding of the cement with the sand.

It may be difficult to anticipate this in actual practice without laboratory experiments to determine the physical condition of the clay. This may be done by elutriation and testing that portion of the clay which cannot be drawn down within a certain period of time by sedimentation, and which remains in suspense, thus indicating its colloidal state, which prevents the actual bonding of the cement with the aggregate, and, therefore, setting of the concrete.

I have in mind two instances of failure directly traceable to the condition last named, and upon washing the sand and gravel before use good results followed.

Mr. Leonard C. Wason. — I can almost begin by saying that so much has been said and so well said that nothing is left for me to say. But there are a few thoughts I would like to bring out or suggest to you. The first is what is to be determined as standard tensile strength for cement. Some time ago I had an experience with a specification for cement which specified the upper limits of the American Society for Testing Materials. A certain cement was submitted to those tests. The 1 : 3 sand test passed at 7 days below the maximum and above the minimum, but was not permitted to be used pend ng the 28-day

test. During this period the cement was submitted to three other laboratories, all of the very highest standing, and there both the neat and sand 7-day and the 28-day tests were conducted and the cement passed every test satisfactorily in all the laboratories. In this first laboratory referred to the neat tests were all above the specified amount, namely, the maximum of the standard specification, but the sand tests were not. The cement was not permitted to be used. Now, while it is probably allowable for the engineer to reject the cement on that small technicality, it does not seem to me to be perfectly just that he should do so. This experience has not shaken my confidence in the cement, but has discredited the laboratory. And in cases like this I think it would be well for engineers to consider a reference to a court of arbitration, say of three or five laboratories; and if they check one another and pass the cement, the cement should be accepted irrespective of any one particular laboratory which finds in some particular respect that the cement is below the standard.

With regard to sand, in the case to which Mr. Thompson referred, the sand seemed to me with the ordinary quick test to be entirely satisfactory. Rubbed between the hands, it was sharp and gritty, left very little residue or silt; thrown into a glass of water, it showed very little clouding of the water; even when the water was stirred vigorously it was not materially clouded. The appearance of the concrete was one thing which seemed to be peculiar. I don't know how to explain it. I simply state the facts and would like to have you produce the explanation. The surface which is exposed to the air was fairly hard, — not as hard as thoroughly first-class concrete, but fairly hard, and the thickness of this shell was pretty uniform. You might compare it with the cover of a book, a little bit thicker than that, possibly one fourth to three eighths of an inch. There was just as much separation of that skin from the mass of concrete as there is of the cover from the pages of the book. The material below was just as soft as could be; you could drive a carpenter's hammer into it nearly to the claw without much effort. Relatively the outer skin was hard, and what was within gradually became hard if exposed.

I had an experience five or six years ago, not as disastrous as the one referred to, but I think due to somewhat similar causes. A dealer presented a sample of sand which was beautiful in appearance. It was light gray and apparently as clean as Newburyport sand. It was uniform in the size of the grains and

had more the appearance of beach than bank sand, although it came from a high elevation where there had been a flower garden. Without stopping to test it, this was incorporated into concrete and the concrete turned out very poor indeed. We had no question of the quality of the cement, but inasmuch as we had completed work upon this, we endeavored to save it. Here the same appearance was observed as I just mentioned — the skin was hard where it was exposed to the air, and inside of this the cement was soft. We let the forms stay on two weeks. It was still just as soft and muddy as before; you could dig it out with your fingernails to a depth of an inch without difficulty. This work went partly into a wall one story high and partly into a floor supported by the wall. And on both floor and wall we removed the forms, a board at a time, here and there. This dried out and hardened, so that at the end of a week it would ring when struck with a carpenter's hammer as well as perfect concrete. But when we would take out the adjoining board we would find it soft and muddy. We continued this process and at the end of about six weeks we had the forms entirely removed. The concrete is now satisfactory. The building — a storage warehouse — has been standing six years and has given no trouble whatsoever. But that peculiar condition of hardening on the surface first and then seeming to harden through the mass and hardening by drying rather than by chemical action, as we might expect from cement, is what puzzles me.

I have seen specifications which specified the color of sand. One architect in particular always specified light gray. Now in other parts of the country, like New Jersey, for instance, you get very red sand, full of iron, and it gives excellent results. Here we get sands which are yellow and gray and other variations of color, and all give excellent results. It seems to me that color has no bearing whatsoever upon the subject. I have seen in specifications frequently the words "foreign materials"; — sand should be sharp, clean, free from foreign materials. What is to be considered foreign material? Sometimes you find mica. That is purely mineral matter; is that foreign? Suppose there is decomposed granite; there is sure to be mica in it. Mica is a bad material for sand; gives very poor results. That word "foreign," it seems to me, is not sufficiently explicit to be used in description without further elucidation.

Sand ought to be tested, certainly, on all important works; and in my own practice on all important works it is customary to test sand when it comes from any new source. Sometimes such

sand may be found away above standard sand; sometimes below. Sometimes sand varies in quality in the same pit. If you should specify an arbitrary 7-day test for sand and have the material stored, because of the bulk it would be difficult to find storage room on a good many operations, especially here in the city where storage room is exceedingly scarce. But suppose it is necessary, because sand is variable, it would be possible to sample the sand in the pit and not allow it to be shipped until reports have been made. In this way the expense of handling large volumes of sand and storing it while the seven-day test is being made could be reduced to a minimum.

When I began concrete construction the standard mixture was 1: 3: 6 for floors, walls and practically all use. And I think that with first-class materials and workmanship that mixture is perfectly satisfactory to-day. Nevertheless, the most common specification now for this class of work is 1 : 2 : 4, and I think this is usually wise as a factor of safety. It is not common to test every bit of your work, to inspect every batch, and, therefore, if you have a rich mixture you can stand for some variations and defects in your aggregates and still be sure that your results will be within the limits of weakness. But if you have a job of sufficient size and want to spend enough money for inspection all the way through, it is possible to save the cost of inspection by a leaner mixture and still get thoroughly satisfactory results.

Nothing has been said yet about thoroughness of mixing. I will mention this very briefly, as the figures I give have all been published as comparisons between hand and machine mixing. I made some tests at the Watertown Arsenal in 1897, comparing hand mixing and machine mixing. Both were a little better done than is usual in commercial practice, and the results showed 11 per cent. greater strength from machine mixing than from hand mixing. In some later tests, where commercial practice was exactly followed under very careful supervision, the difference in strength was 25.4 per cent. in favor of machine mixing. Now this shows how thoroughly mixed concrete will help to overcome the difficulties of imperfect aggregates. An aggregate might fail with hand mixing and pass satisfactorily with machine mixing.

I also want briefly to mention in this connection some test-specimens made at the Institute of Technology some years ago. I made the specimens for the students to test as thesis work. There were columns 8 in. square and 16 or 17 ft. long. It was difficult to pack them carefully, and some of the specimens were

very badly honeycombed. But the interesting feature is that although quite a percentage of the cross-section of the 8-in. square column was lost by the honeycombing — in some cases 3 or 4 in. — those specimens tested so near the average of perfect specimens that you could not attribute the loss of strength entirely to the honeycombed character of their surface. I think some engineers have overdone the matter of condemning concrete which has been rough on the surface. In certain cases, I know, such work should not be passed, but in many cases I know it is condemned where it would not produce any bad results whatsoever.

Lastly, regarding the tamping of concrete. I have no actual tests of my own, but I have in mind tests made by another man to compare tamped with untamped concrete. This, of course, was not the sloppy mixture we use in reinforced concrete, but the plastic mixture which can be tamped, and the difference was 30 per cent. in favor of the tamped concrete. The very wet, sloppy mixtures we have to-day I think are somewhat weaker than mixtures a little less wet. But I think possibly this source of weakness is overcome by the richer mixture we now use.

Mr. Worcester. — I just want to say that the testing of sand in the pit as advocated by Mr. Wason appears to me to be a snare and a delusion. The fact that the pit contains all sorts of sands is the very reason why it is no use to examine it there. The men in taking it out of the pit and shipping it to the job may intend to take out the right kind, but unless you have a tester there every time a car is loaded, they are pretty sure to get the wrong kind.

The Chairman (Mr. H. F. Bryant). — I would like to ask Mr. Thompson, when he spoke of a sand pit where it appeared that vegetable matter had come down from above, whether he meant that the vegetable matter had come down before the sand pit was worked, or during the working of it?

Mr. Thompson. — The appearance of the face of the bank I spoke of was from material which came down after the cut was open. I mentioned it as a probable explanation of the way the material had worked down through the sand before the pit was opened. In other words, it had gone on faster when it had a face.

Mr. R. R. Newman. — I have in mind a case which I think will be of interest in corroboration of Mr. Thompson's statements about vegetable matter. This was in connection with the building of filters. The same sand bank was used for sand in concrete as was later used for sand filter material. It was good sand and

everything was satisfactory regarding its use on the orignal construction. After the filters were in operation for a while and we had scraped off some of the corroded sand — sand that had become dirty — and thrown it into a pile at one side, there was a little job of concreting came up and we used some of that dirty sand — the same sand dirtied by vegetable matter. It set up very slowly indeed, showing just the effect Mr. Thompson spoke of. I should say further that the dirt in the sand was purely vegetable in character — there having been no heavy storms and no roily water having passed through the filter.

Mr. Bertram Brewer. — Mr. Sherman said something about the range of temperature in which briquettes are kept and tested, and spoke of testing out in the field on the work where briquettes are sometimes allowed to freeze. I would like to ask Mr. Sherman if he can tell us anything about the difference in temperature as affecting the strength of the concrete and what range is allowable in his experience, or, rather, how much of a change of temperature it takes to make a material difference in the strength.

Mr. Sherman. — Some time ago I made some tests for the Aberthaw Construction Company in cold storage to bring out this point. We made briquettes and stored them in rooms of four different temperatures. One of these was 72 degrees, if I remenber rightly; one was 34 degrees, one was 6 degrees above, and one was 7 degrees below zero. Those temperatures are approximate. We carried on tensile strength tests, on these briquettes for, I think, a year — at any rate, for some time — and we found that briquettes stored at the two temperatures below freezing gave no strength on 1 to 28-day tests, as we expected. The briquettes stored in the normal temperature of 72 degrees gave very good strength, and those at 34 degrees also gave very good strength. It appeared from those tests, so far as we carried them, that anything above freezing gives fairly good strength. The line seems to be 32 degrees, so far as we have tested. But in connection with this it was interesting to note that on a three-months' test the briquettes that were made in the rooms at 6 above and 7 below had some strength. These were taken to the laboratory from cold storage and allowed to thaw out. They had showed up to that time absolutely no strength; in fact, the cement hadn't even set. But at three months we found the cement had set and, on thawing out, the briquettes were fairly hard and gave some 15 or 20 lb. tensile strength, if I remember rightly.

Mr. Brewer. — One hesitates to tell his experience before such a gathering of experts. But I would just like to say that my experience corroborates the statement of the last speaker. I had a little experience in my our laboratory of that sort this last winter. I am sorry that these speakers don't think young engineers ought to have laboratories of their own, but some of us are inclined to think otherwise. At any rate, we want to try. My own experience along this very line was this. A sample of cement was submitted to me by a local dealer who wanted to carry it in stock. He could get it at a low figure and wanted to know if it was all right. We tested it and found that it fell down on the 24-hr. and 7-day tests. Two or three weeks afterward I had a call from the regular tester of the company, who was very much disturbed over the results we had secured, and, as is customary in such cases, I told him he might try it with my tester and work with him and see how he did it. He did not get as good results as my man did with the same cement. He then suggested that the reason was that my testing was done at a temperature below the standard. We tried it afterward at the standard temperature and found it made no difference whatever. In this case the temperature was about 25 degrees below the standard.

Mr. Sherman. — I do not wish to go on record as saying that young engineers should not test cement. What I wish to emphasize is that cement testing is a business. It is not a thing, as I said before, for a draftsman to do in his spare moments, while his business is something else. It is a business, something that requires a great deal of thought. It is not, of course, an exact science, but it takes a great deal of careful work.

Mr. Thompson. — There was one statement made by Mr. Wason to which I wish to take exception, because I think it may give a different impression from what he intended. That is, with reference to the gradation of the sizes of the grains of sand being no indication of the quality of the sand. I agree in general in his conclusions as to the necessity of testing, but I know he will agree with me that, provided a sand does not have some of this deleterious material in it, provided it is a clean sand, the gradation of grains does affect it a great deal, for a fine sand can never give a good mortar.

The Chairman. — I wish to recite one thing that happened a year ago in my own experience. I have not been on the work since it was done, and can only say how it looks from the report of others. The engineer in charge was unable to secure any

very satisfactory sand for this particular work. At the same time he was experimenting under my advice in the use of clays to make a watertight surface with the cement. And this very miserable sand, mixed with clay, gave remarkably good results on a three-months' test. I don't know anything about the reason, but it is a fact that a sand that did not stand up well alone showed up well when mixed with clay. If anybody has any explanation to offer of that, I would like to hear it.

A MEMBER. — What percentage of clay?

THE CHAIRMAN. — Somewhere between 5 and 10 per cent. gave the best results. The clay was dried and pulverized and then mixed a good deal like cement and added to the sand.

MR. LARNED. — In my discussion of the influence of clay on sand, I believe I said that if a sand was treated with a percentage of clay carefully dried and pulverized and thoroughly mixed it might give good results. This is laboratory work. But in my experience I have never seen sand containing an appreciable amount of clay that gave satisfactory results in practical work. It is quite likely that such things occur and may give good results, but I have never seen it. On the question of mixture, Mr. Wason referred to the popular mixture of 1 : 3 : 6, and the tendency in later tests to increase the richness. It perhaps might put me under suspicion to speak very directly or emphatically in favor of a richer proportion, because, of course, it involves a greater use of cement. But if you will believe me, I am speaking entirely independent of that, and I think I can convince you.

A 1 : 3 : 6 mixture, if perfectly made and carefully handled in the work, will undoubtedly give you very good results. But the six parts of stone must be pretty carefully selected with regard to relative sizes or you will have a concrete with mortar very poorly proportioned, and the sand must be coarse and fairly well graded in size or the cement will not fill the sand voids. And if in the process of mixing and transportation to the forms the concrete is broken up into small units, you will not get the concrete as it is mixed either by a mixer or by hand. You will get portions very fat and portions very lean, and it will go into the work just that way. Some portions of the work will be well filled and dense, and other portions will be full of voids and poor in quality. The small cost of additional cement is really a very small factor. Just on the basis of present prices of cement, I have drawn up a statement showing the difference between the cost of the lean and the fat mixture.

Cost of cement per yard of work: 1 : 2 : 4 mix, present price

of cement, $1.85; 1:3:5 mix, $1.43; 1:3:6 mix, $1.28 per yard of concrete.

Now, assuming that the concrete costs $8 per yard in place, the cement in the 1:2:4 mix costs 23 per cent. of the total cost; 1:3:5 mix, 18 per cent., and 1:3:6 mix, 16 per cent. You see there is a very small difference between the 1:3:5 and the 1:3:6, and very little more in the case of the 1:2:4.

Now comes the reinforced concrete, costing $15 per yard, and that covers wall work, or retaining wall work, or perhaps difficult forms of foundation: the 1:2:4 mix would cost 12.3 per cent. of the total cost per yard of concrete; the 1:3:5 would cost 9.5 per cent., and the 1:3:6 would cost 8.5 per cent. of the total cost per yard of concrete.

In case of more intricate reinforced concrete work, as beams and girders, the price will readily run up to $25 a yard in place, and oftentimes much more; but assuming it does not cost any more than $25 a yard, the cost of the cement in the 1:2:4 mix would be 7.4 per cent. of the total cost per yard of concrete; the cost of the cement in the 1:3:5 mix would be 5.7 per cent. of the total, and of the 1:3:6 mix, 5 per cent.

On the basis of that showing, there is very little inducement to skimp on cement, it seems to me. The additional factor of safety cannot be overlooked, because I don't care how well the job may be organized, or what attention may be given to it in the way of inspection, inequalities will creep in, and that personal equation should be limited just as far as possible; and if that can be done to a large extent by the addition of a small amount of cement at a nominal cost, it is a pretty good step to take.

I believe this, that the time is practically here when mechanical mixing will be insisted upon on any important work of any kind. Hand mixing of concrete has come to be such a perfunctory operation, attended with so many ragged results, that it really should not be permitted on any job of any importance. I believe engineers generally are coming to recognize that. Of course, if it is a small job, involving a small quantity of concrete, it would be a hardship to bring on to the job a mechanical mixer. But a job requiring anything from 500 yd. of concrete up is well justified in having a machine mixer on it.

Another thing which I think is well worth drawing your attention to is the fact that if you want a perfectly mixed concrete, a concrete of such consistency that the aggregates cling together, that is of a mushy consistency and does not separate

on handling, you don't want too much water in it. You want it of a gelatinous nature. You want concrete that can be tamped; you can't tamp water. But if you get it of a gelatinous nature that will cling together, put it in your forms and ram it lightly, or even tread it in with the feet of the workmen in the forms, and you have a concrete that in strength and density is a very superior concrete. And further than that, it develops a strength in the mortar, which, of course, is the strength of the concrete, that you can't get in any other way. Take the prolonged mixing in the laboratory of 1 : 3 mix; it has between $1\frac{1}{2}$ to $2\frac{1}{2}$ min. on the slab. If the batch is held in the mixer only a few revolutions more, you will have, as a rule, better concrete.

Mr. Newman. — In reference to the use of clay in concrete, I can give an instance where sand containing clay was used in preference to other sand. That was in lining a canal in California. Sand containing clay not exceeding 10 per cent. was preferred on the job and gave good results. The canal was 12 miles long and was lined throughout with concrete, and in connection with this work quite a bit of testing with clay mixtures was carried on. We found that with several sands we could add 15 per cent. of clay without reducing the strength at all.

Mr. Sherman. — In reference to adding clay to cement, I wish to emphasize the fact that laboratory tests on these are really not entirely satisfactory. Clay can be pulverized and mixed with cement and sand and thoroughly mixed. Clay as it occurs in natural sand is lumpy, and even though it is worked a great deal, these lumps will still remain as lumps and are just so many weak spots in the mortar.

Mr. Thompson. — I happen to have a record right here of Philadelphia sand. Before washing it contained 6 per cent. that passed the 200 sieve and gave a strength of 200 lb. per square inch. It was a fine sand. After washing it gave a strength of 150 lb. per square inch. The clay was in its natural condition, and yet it did in that case increase the strength of the sand.

The Chairman. — I would like to ask Mr. Worcester whether he still thinks a 70 per cent. requirement on sand briquettes is a proper requirement, or whether he would use some other figure.

Mr. Worcester. — That figure seems to me to be very satisfactory. I have no doubt that sand which develops 70 per cent. of standard sand is good enough. I don't think there is any dangerous percentage of organic matter in it. I wouldn't

know which way to change that, whether up or down, in order to get more satisfactory results.

MEMBER. — What do you call standard sand?

MR. WORCESTER. — I think it is generally recognized that Ottawa sand is standard.

THE CHAIRMAN. — I remember one instance in which a gentleman present had a share where the cement passed a well-known testing laboratory belonging to the government and yet failed to succeed in a certain piece of work in which the gentleman to whom I am addressing myself had a hand, and where other cement made quite a success. I would like to ask him if he discovered what the difficulty was.

MR. WASON. — My solution was the quick-setting cement. The time between mixing it on the work and getting it in place was a matter of about 15 min., whereas in laboratory work the briquettes are gotten into place in 3 or 4 min. The time of initial set was about 10 min. So the conditions which made the concrete fail on the work did not show up in the laboratory, where the initial set was not broken.

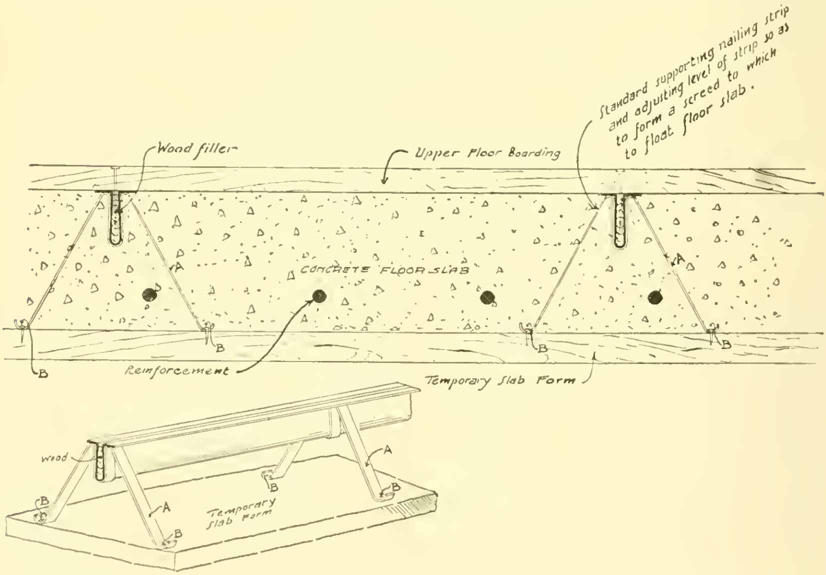
[NOTE. — Further discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by February 1, 1910, for publication in a subsequent number of the JOURNAL.]

METAL SCREED FOR CONCRETE FLOOR SLAB.

By Benjamin Fox, Member Boston Society of Civil Engineers.

[Read at an informal meeting of the Society, May 12, 1909.]

I want to submit for your criticism a metal floor screed designed as a substitute for the wood floor screed that is usually put on top of structural concrete floors. This screed is designed to set parallel with the reinforcement and flush with the upper surface of the structural concrete floor, supported every 2 or 3 ft. by a ribbed metal support "A," that is made beveled in at the top to hold the screed up in position and at the same time prevent it from working up with the tamping of the concrete floor. There are holes in this ribbed piece at "B" for tacking to the form. When in position, the screed also forms a true line for floating the structural concrete to. I will read over the good points I believe it has and leave your criticisms to bring out the bad ones.



The matter of end joints in the wood floor in using a square-edge floor is provided for by cutting the end joints at an angle of 60 instead of 90 degrees; and in the event of using a matched floor this cutting would be unnecessary. I started on this screed on account of the many objections I found among mill owners, who objected to the dust from concrete floors, and among employees, who objected to working on cement floors. This screed

is made of 22 gage metal and is stiff enough with these ribbed supports, about 2 ft. on centers, to take care of any buckling that might occur. My idea is to place the screeds 2 ft. on centers for nailing, instead of the regular 16 in. at which the wooden screeds are put on. Where a wood floor is a necessity, it saves in the height of the building. The thickness of a wood screed is 2 or 3 in., and on a ten-story building that means 20 to 30 in. saved in the height of the building, with a proportionate saving in the cost. There is no question about its staying where it is put, or of the floor staying where it is laid; this is not the experience with wood screeds. With the ordinary wood screed any warping of the upper floor will twist the screed. Another thing in its favor is that a square-edge floor can be used with this without the fear of the dusting through of the concrete underneath. With the square-edge floor and the wood screed, the working of the wood floor will powder the cinder concrete fill and let it dust up through the square-edge floor. The laying of a new floor in the place of an old one in which the wood screed is used is quite an undertaking, involving the tearing up of the screeds. With the metal screed it is only a case of taking up the floor and laying another one in its place. Another thing is the accurate placing of machinery on this screed. Many owners find it hard to locate machinery before the building is complete. With the wood floor nailed in this metal screed the machinery can be expansion-bolted through the floor into the concrete and moved around in any location afterward and expansion-bolted through the floor.

This screed is to run parallel with the reinforcement. The question may come up of the weakening of the slab by the lessening of the cross-section of the slab. But it seems to me it would only crack at such places as an expansion crack would occur in any case. As an illustration of the holding power of the nails, I will drive a nail into this sample which I have brought along. I think you can judge by the sound of the driving of the nail into the screed that it will hold.

There is one thing I did not speak of. I provide in this beveled space for a wood filling piece, and instead of depending entirely on the gripping of the nails on the sides of the beveled screed, I fill the space enclosed by the metal with a wood strip and the nail goes into it. This wood strip prevents the cement grout getting in the space. I tested the holding power of those nails and found it very much stronger than that of the nails going into a wood screed. I think those are all the points I want to make.

[Note. — Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by February 1, 1910, for publication in a subsequent number of the Journal.]

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A MODERN BOILER SHOP.

BY E. R. FISH, MEMBER OF THE ENGINEERS' CLUB OF ST. LOUIS.

[Read before the Club, November 13, 1909.]

THE design of a factory for building steam boilers and doing the kind of sheet metal work allied thereto is not as intricate a problem as that of most other lines of manufacture. There were some interesting features, however, connected with the building of a recent plant that may be of service to others. As an illustration of a modern factory of this kind, this description of the Heine Safety Boiler Company's new shop at St. Louis, Mo., is presented.

GENERAL PLAN.

The property on which the shop is located lies at the intersection of East Marcus Avenue and the west belt of the terminal railway, a double track main line. In shape it is a trapezoid, one end being perpendicular to the sides, the other being at an angle of about 45 degrees. The four sides are, respectively, 259 ft., 512 ft., 771 ft., 836 ft., an area of 6.5 acres. It is along the oblique side that the railroad passes, Marcus Avenue being the boundary of the short side. A small stream meanders approximately on the railway property line. (Fig. 1.) The original surface of the ground sloped from an elevation at the creek bank of 24 ft. above the city datum to 67 ft. at the inner corner. The grade was fixed at 47 ft., that being the elevation of the railway tracks. To prepare the ground for building it was necessary to excavate the higher and fill in the lower portions of the site. There was just about enough material to fill in as much

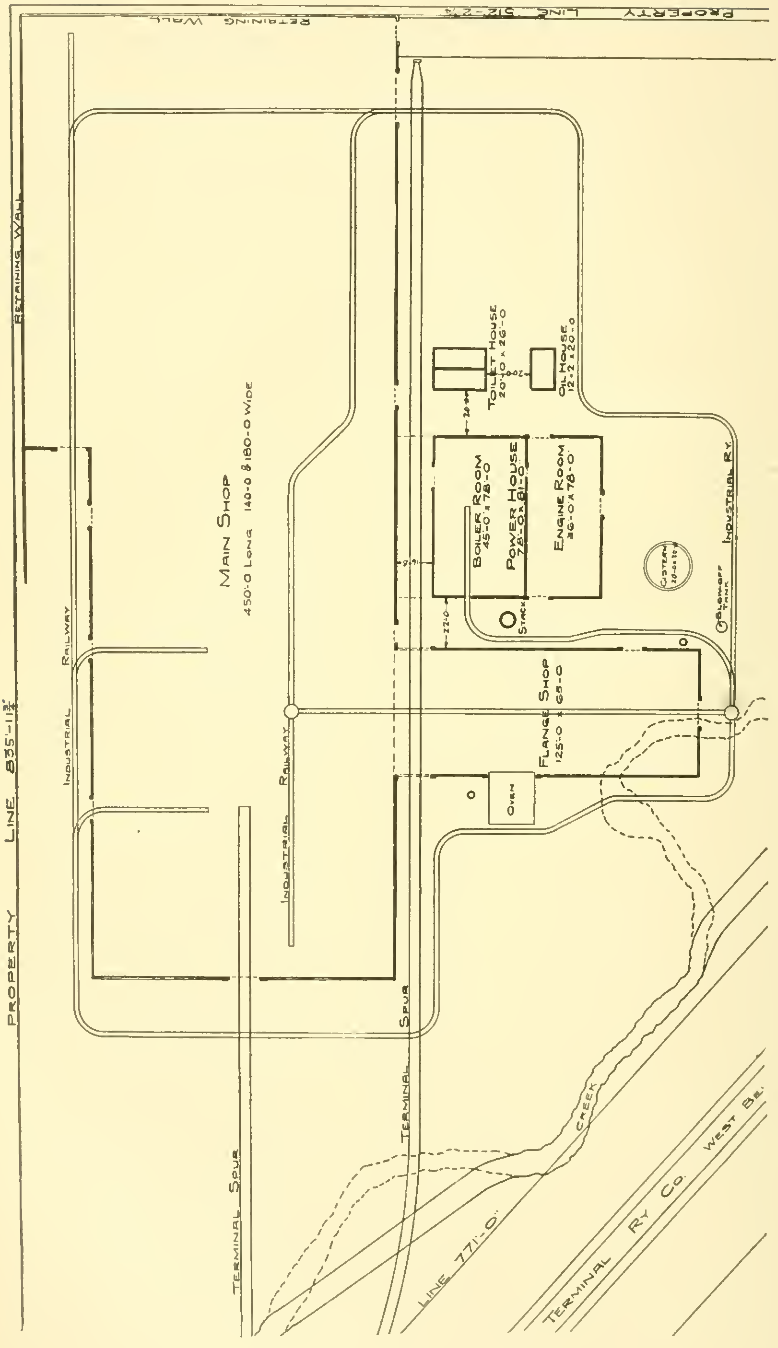


Fig. 1. General Plan.

of the lot as was required for immediate use, leaving a considerable area for the future disposition of cinders, etc. The stream was straightened in two places. A large municipal trunk sewer will soon be built along its course, after which the entire area will be available for such use as may be desired.

A reinforced buttressed concrete retaining wall with a maximum height of 19.5 ft. above grade at the corner and stepped down on the end and side, following the slope of the hill, is built 4 ft. inside the property line so as to keep the wide footing within the site. This wall forms a part of the end and side of one of the buildings.

The buildings consist of a main shop, flange shop (which is a wing of the main shop), power house, toilet and wash house, oil house and general office, totaling about 2.5 acres of floor space. The relative locations are shown on Fig. 1.

The shape of the property made the location of the switch connections simple and convenient. They enter with long radii curves, becoming tangents parallel to the buildings before reaching them. At present there are two switches, one of which enters the main shop and is the shipping track; the other passes alongside of the main shop between it and the flange shop and power house and is the receiving track. It is anticipated that another switch will be placed along the opposite side of the main building when conditions demand. A 100-ton 42-ft. extra heavy Howe track scale is located on the railway right-of-way near the connection to the main track. The office building is on the opposite side of the property facing Marcus Avenue, far enough away to avoid serious interference from the noises of the shop.

In general, the raw material is received at the far end of the large building, that being the storage space. During the manufacturing processes it passes without reversal to the opposite end, where the completed boilers are stored and shipped. Tubes, not being needed until boilers are assembled, are received and stored at this end. The whole floor area of both main and flange shops is served by large or small traveling cranes, while a 24-in. gage Koppel industrial railway completely encircles the structures, with connections in the interior, so that the handling of material of all kinds may be carried on with the least expenditure of time and energy. A roadway leads from Marcus Avenue into the receiving end of the main building. A portion of the interior of this building is partitioned off for a machine shop to do the little work of that nature required in the manufacturing processes and to care for the ordinary repairs and maintenance of the plant.

Three sources of power for the operation of the equipment are used — electric, hydraulic and pneumatic. All the generating machinery is located in the power house, which is placed in close proximity to the hydraulic and pneumatic tools, in order to reduce the length of the transmission lines, a saving both in first cost, frictional losses and maintenance. The great majority of the tools are electric driven by individual Wagner motors wherever practicable.

It is believed that the buildings as erected are amply large for some years of growth, so they are built with permanent ends; but, when conditions demand, the main shop may be extended toward the railway and the flange shop toward Marcus Avenue. Also a wing or separate buildings can be built along the rear end of the lot as an extension of the main shop.

As far as practicable all water is saved, to effect which a drainage system is provided into which all rain water from the roofs, as well as the clean waste from manufacturing processes, is discharged. This system discharges into a large cement-lined cistern 20 ft. diameter by 20 ft. deep near the power house. As the only source of water supply is from the city mains, this arrangement effects a very appreciable economy.

Type of Building.

The several buildings are all of the same general type, all structural details being standardized as far as practicable. At the outset it was determined to eliminate the fire hazard, and to build durably and yet have a maximum of natural light in the interior, which meant large window space. Steel frame structures with outside walls of brick and reinforced concrete slab roofs were accordingly adopted, with full-length monitors in the middle in order to obtain additional light and ventilation. About 75 per cent. of the vertical areas exclusive of the retaining walls are glass. One size of window pane is used throughout, this being a commercial size, 12 in. by 16 in. The advantage of this will be appreciated when it is understood there are over 22 000 panes in the several buildings. Wood is used only for window and door frames and doors, the machine shop and sheet iron shop floors.

Construction.

Main Shop.

This building is 450 ft. long by 143 ft. wide for 250 ft. of its length, and 180 ft. for the remaining 200 ft. It is of this latter

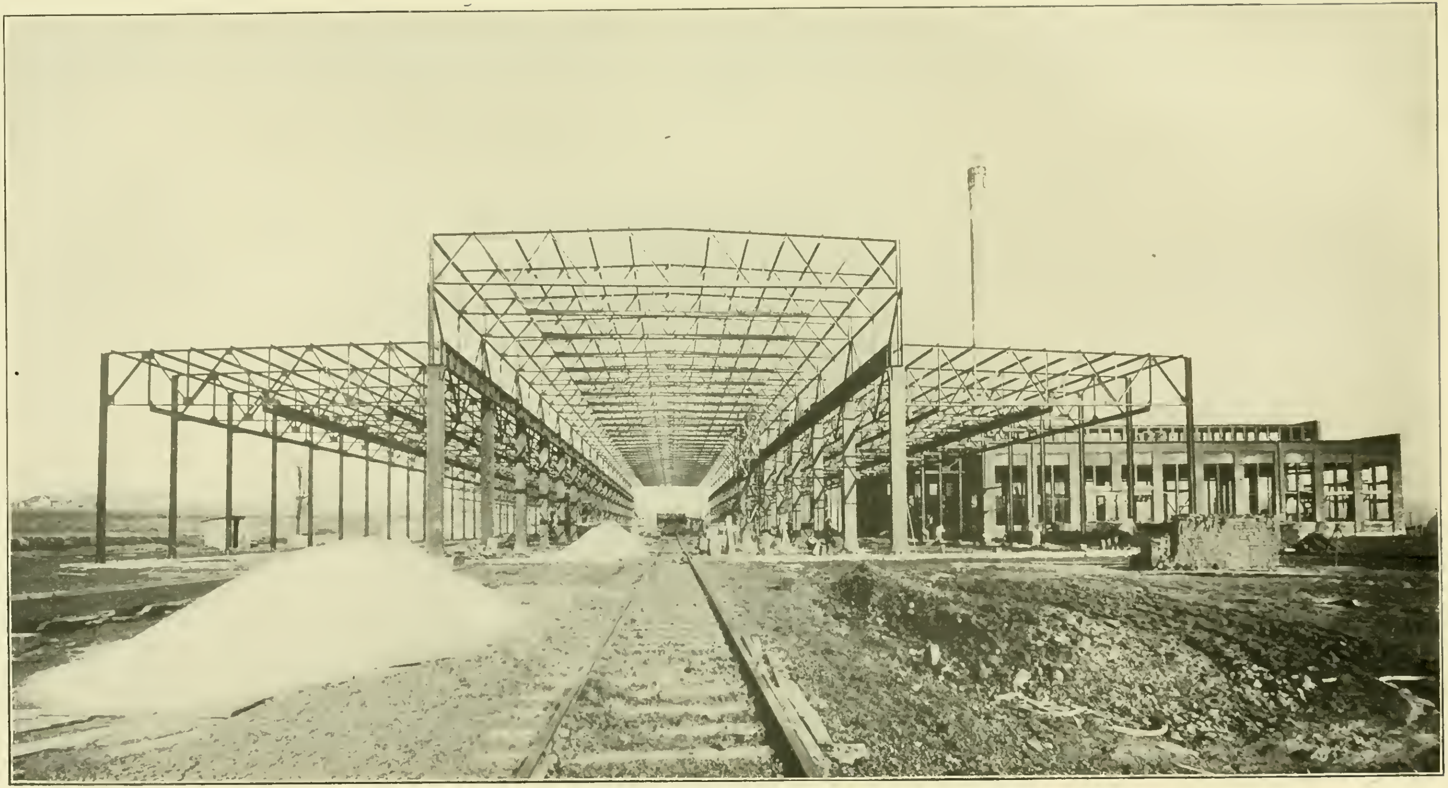


FIG. 2.

part that the retaining walls form one side and end. The narrow portion is divided into three longitudinal bays, the middle one being 60 ft. wide, and the two side ones 41.5 ft. The increase to 180 ft. is made by the addition of a fourth bay of 37 ft. The design of the steel frame follows standard practice, being calculated for the dead and live loads imposed by the roof and traveling cranes, the runways for which are 9-in. I-beams hung to the lower chords of the roof trusses, with the exception of the large crane way, which is carried directly on columns. The roof trusses are spaced 12.5 ft. centers, carried on the columns forming the bays. The columns of the central bay are spaced 25 ft. centers longitudinally, 60 ft. transversely, and carry the 25-ton traveling crane way. The spacing of trusses thus provides stiffeners at the center points of the main crane runway and provides spaces of only 12.5 ft. for the support of the smaller crane runways in the side bays. The roof of the middle bay is 14 ft. higher than that of the side bays, thus forming the monitor in which the principal crane runs. (Fig. 2.) About the middle of the side toward the power house is the riveting tower, 100 ft. long by 24 ft. wide, its roof being 55 ft. above the floor. The steel work of this tower is framed into that of the building proper.

The outside walls are of brick with concrete footings and completely enclose the outer steel columns. The outside columns carrying the trusses of the fourth bay rest on the retaining wall, which also serves as a foundation for the brick walls that close the end and side of the building at these points. Practically all the windows in the walls are 9 ft. 8 in. wide by 17 ft. 5 in. in height, this being the standard size for all buildings. The stone sills of the windows are 3 ft. 2 in. above the floor line, while the tops are practically at the height of the lower chords of the roof trusses. Each of these openings has two vertical rows of three sashes, each 3 ft. 5 in. by 5 ft. 10 in. high, and of the same construction. The middle sash is stationary; the upper and lower sashes are arranged so that they can be raised and lowered vertically. They counterbalance each other through steel chains over special pulleys at the top of the window frames, so that by raising the lower sash any degree of opening of the windows from nothing to two thirds is very easily and conveniently accomplished by one man and from the floor level. The windows over the retaining walls at the rear end and side are arranged so as to utilize as much of the space between the top of the wall and the roof trusses as is practicable.

Both sides of the monitor are practically all window space

there being two rows of sashes which are also each 3 ft. 5 in. by 5 ft. 10 in. in size. Those in the lower row are stationary; those in the upper row are pivoted at the middle so that they can be opened for ventilating purposes. One side of this monitor is unbroken, but the opposite side is divided into two sections by the riveting tower. Double rows of windows arranged similarly to those in the monitor are placed in both sides and ends of the tower. All the pivoted windows in the unbroken side of the monitor are operated in two sections of equal length, each by means of a single Lovell window operating device. The two sections on the opposite side are each operated by a single device of the same type.

The upper row of sash on two sides of the riveting tower is likewise pivoted and operated. (Fig. 5.)

The standard size of door opening is 9 ft. 8 in. by 12 ft. high, closed by two equal swinging doors, one of which contains a small door to permit employees to pass easily into and out of the building. Above these doors are two stationary window sashes of the standard size. In the receiving end is located a special door opening 22 ft. 2 in. wide by 20 ft. high. Through this is carried a transverse crane way 18 ft. $8\frac{1}{4}$ in. span projecting outside of the building over the receiving track, the outer end being carried by "A" frames. (Fig. 3.) This connects with the longitudinal cranes in the inside, thus permitting the unloading of material from cars expeditiously and cheaply. This large opening is closed by means of a special variety rolling steel door carried on trolleys which run on the crane way. The carriage for this door is covered with a hood which entirely closes the opening above and between the beams when against the building, the door and its rolling mechanism being suspended below the crane way beams. When in this position the rolling door lowers into the guides provided at the side, and when it is entirely rolled up the whole carriage may be moved to the outer end of the crane way, thus giving an unobstructed passage for the traveling crane and at the same time preserving the continuity of the crane way. This special door was made necessary because of the extreme size of the opening and by the governing conditions which rendered any other type of door impracticable. The door and carriage are operated by means of gears and hand chains. The hood so protects the mechanism of the carriage and the door when it is rolled up that it can be left exposed at the outer end of the crane way without harmful results. Although the door is of large dimensions, it can be

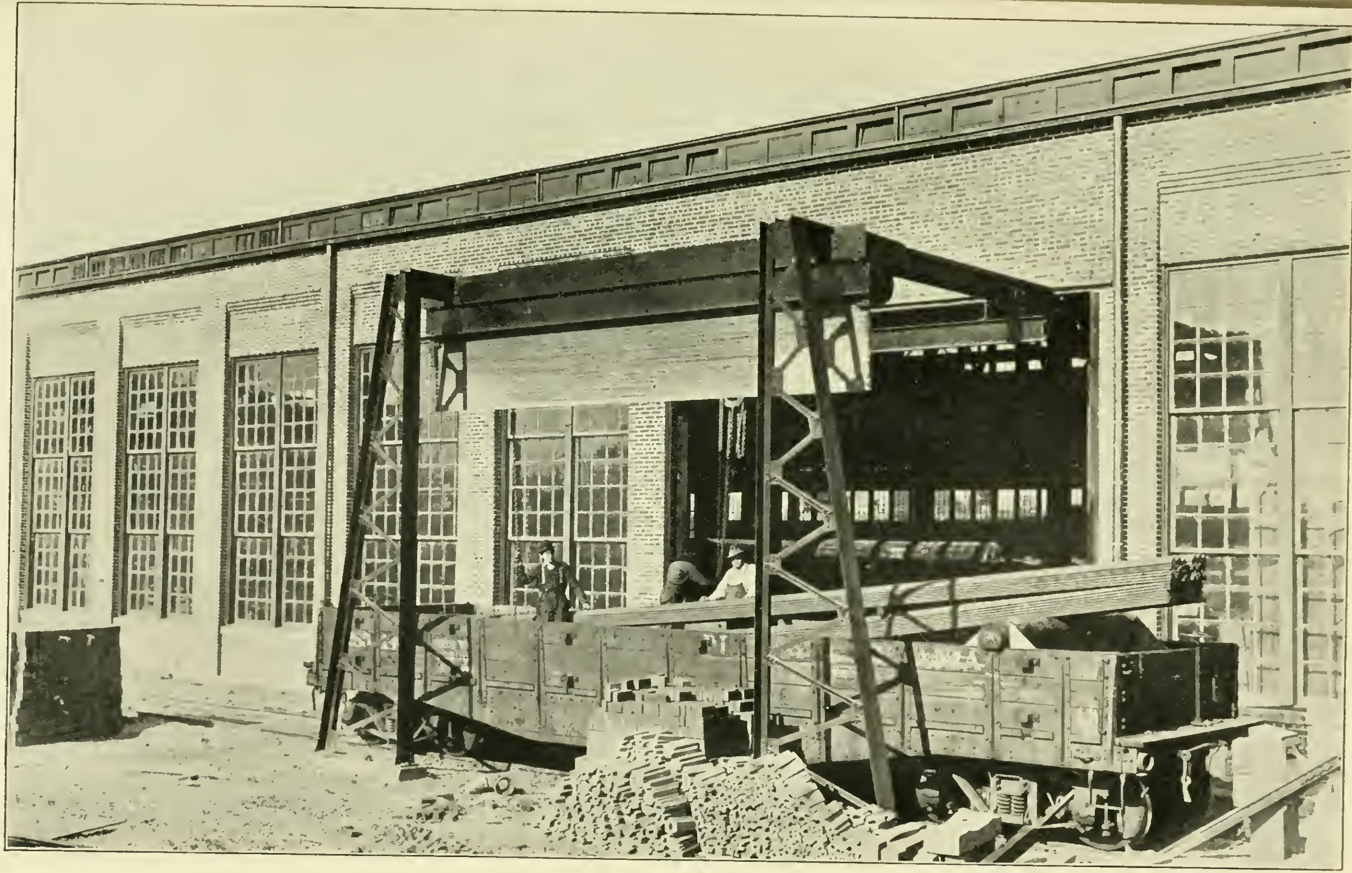


FIG. 3.

width of the building, leaving the floor area unobstructed, and carry two parallel traveling crane ways of 9-in. I-beams with 18 ft. 8 in. span, hung from the bottom chords, below which there is a clear height of 20 ft. This building has a monitor 13 ft. wide by 9 ft. high, made of light frames supported in the middle of and by the roof trusses. The window arrangement is exactly the same as in the main building except that the monitor has but one row of pivoted sashes on each side operated by a Lovell device. Door openings 16 ft. 10 in. wide by 20 ft. 9 in. high are placed in the side walls at the ends next the main building through which the receiving switch passes. These openings are closed by Kinnear rolling steel doors so that cars can be operated through the building on this track.

In one side of the building an opening is left in the wall for the large heating furnace, which is housed in a small steel frame structure placed against and outside the wall.

One of the outer corners of the flange shop is over a fill and a part of the original creek bed. This made it necessary to carry concrete footings down 24 ft. to bed rock. These footings are in the shape of concrete columns, carrying reinforced concrete beams just below the floor level, which, in turn, carry the steel frame columns and the brick walls. A standard door is in the middle of the outer end.

Power House.

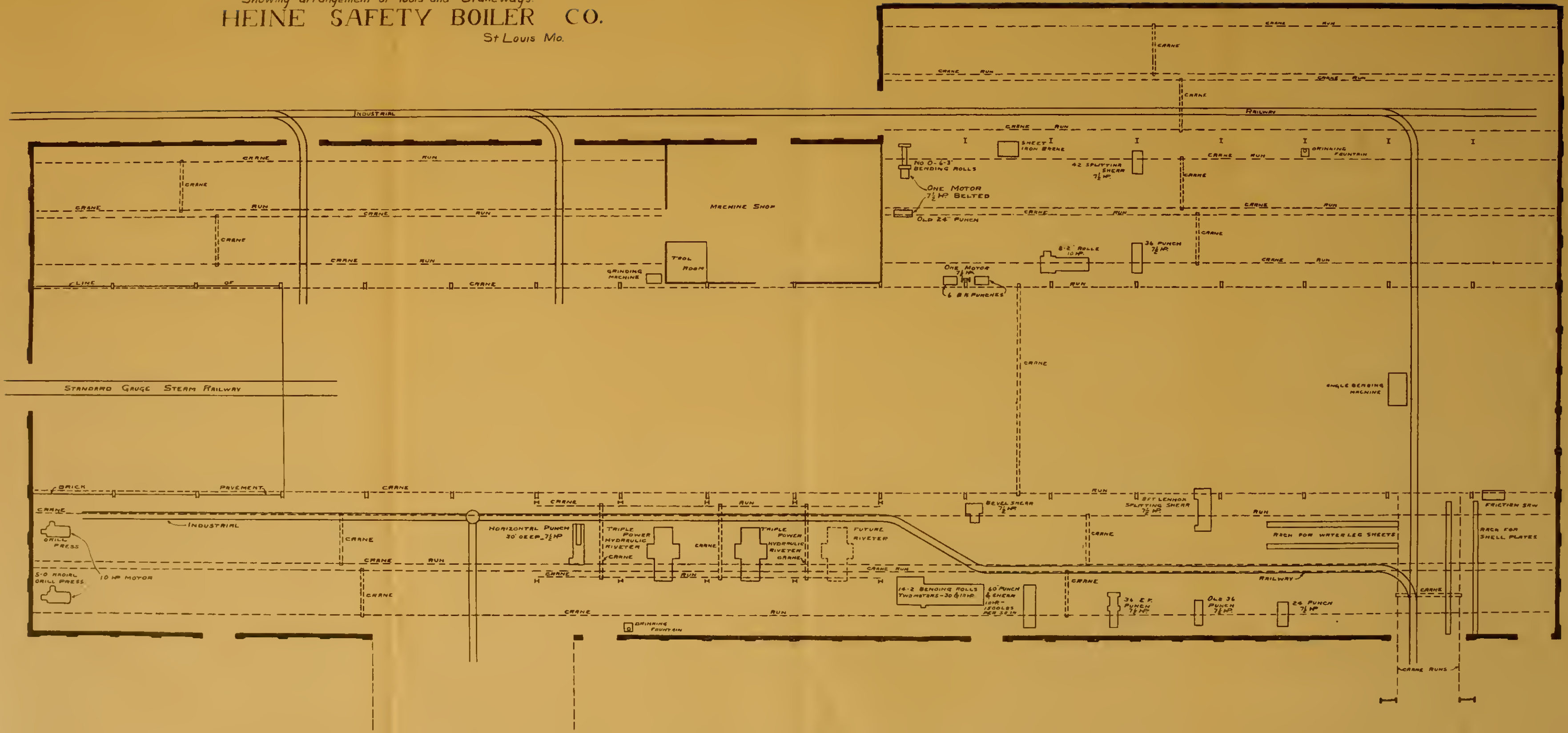
This building is 75 ft. wide by 79 ft. long, being separated by a distance of 22 ft. from the flange shop and 16 ft. 10 in. from the main shop. In the main, its construction is the same as that of the other two buildings (Fig. 5), the main difference being that it is divided into an engine room, 34 ft. 7 in. wide, and boiler room, 42 ft. 11 in. wide, by a brick wall in which is located a row of columns carrying the abutting ends of the roof trusses. The monitor, 13 ft. wide by 50 ft. long, with windows similar to those heretofore described, is half over one room and half over the other, the partition wall extending to its roof. The middle row of columns and the outer row carry the runway of an overhead traveling crane serving the engine room. The roof is continued over the space between this and the main building in order that coal cars may be unloaded without interference by the weather. The entire floor of this building is at the same level, made of concrete and provided with necessary pipe trenches, which are covered with iron plates. The outer wall of the boiler room is carried up solid to the coal holes, a height of 8 ft.

PLAN OF MAIN SHOP

Showing arrangement of Tools and Craneways.

HEINE SAFETY BOILER CO.

St Louis Mo.



The coal holes are opposite the boilers and are 3 ft. high and 10 ft. long, with heavy iron frames set in the brickwork and closed with iron doors. Above these coal holes is a row of windows.

Toilet and Wash House.

This is located 16 ft. 10 in. from the main shop and 20 ft. from the power house, where it is accessible with a minimum loss of time. (Fig. 5.) It is a one-story brick building, 20 ft. by 26 ft., with a concrete roof and floor and divided by a brick wall into two rooms about 9 ft. wide, one of which contains ten wash down closets and an iron enameled urinal, both with automatic flush; white enameled wash sinks with numerous hot and cold faucets are in the other room. A galvanized house boiler, heated by exhaust steam, furnishes a supply of hot water. Lighting is by small windows near the top of the walls. The sewerage is carried by a sanitary sewer to the creek at the far corner of the lot.

Oil House.

This is a one-story brick building 12 ft. by 20 ft., with a concrete roof and floor, located 20 ft. from the toilet house and 20 ft. from the power house, from which it can be quickly reached. It is intended solely for the storage of inflammable liquids, etc. (Fig. 5.)

Equipment.

Main Shop.

In this part are stored all the raw material, supplies, etc. Most of this storing is done at the extreme rear end and side where there is the least light, yet where it is accessible and easily removed to any point where it may be needed. A 3-ton Yale & Towne traveling crane on the transverse crane way heretofore mentioned serves the delivering track and places the boiler plate, which is the heaviest material received, directly into a series of racks that hold the plates in a vertical position so that any plate may be withdrawn without unnecessary handling. The side bays are each served by four 3-ton 14-ft. Curtis traveling cranes, with hand-operated triplex blocks running on two adjacent parallel crane ways in each bay hung to the bottom chords of the roof trusses.

This shop contains tools as follows. The motor sizes given indicate that the machine is driven by an individual motor.

1 Ryerson high-speed friction saw, 30 h. p. motor.

1 24-in. Kraut punch, 7½ h. p. motor.

1 36-in. Cleveland punch, 7½ h. p. motor.

1 8-ft. Lennox splitting shears, $7\frac{1}{2}$ h. p. motor.
1 60-in. Cleveland punch and shear, 10 h. p. motor.
1 Lennox rotary bevel shear, $7\frac{1}{2}$ h. p. motor.
1 14-ft. Hilles & Jones bending roll, 10 h. p. and 30 h. p. motors.
2 100-ton Woods triple power hydraulic riveters.
1 30-in. Long & Allstatter horizontal punch, $7\frac{1}{2}$ h. p. motor.

The three last machines are located under the riveting tower and are served by three 10-ton Wood hydraulic tower traveling cranes with 40 ft. lift and 20 ft. 7 in. span.

One unoccupied section in this tower provides for an additional riveter.

2 5-ft. radial drills belted from a shaft driven by a 10 h. p. motor, supported overhead on a bracket bolted to the wall.
1 Wood portable hydraulic riveter, which is handled by the hydraulic hoist in the 30-in. horizontal punch tower.
1 25-ton Pawling & Harnishfeger electric traveling crane, $26\frac{1}{2}$ ft. lift, 60 ft. span, with 5-ton auxiliary hoist, with General Electric motors for all movements.

An outfit of pneumatic calking, riveting and chipping hammers.

Also the following sheet iron working tools:

1 angle-bending roll, 10 h. p. motor.
1 sheet iron break, $7\frac{1}{2}$ h. p. motor.
1 42-in. Lennox rotary splitting shears, $7\frac{1}{2}$ h. p. motor.
1 36-in. Kraut punch, $7\frac{1}{2}$ h. p. motor.
1 8-ft. Hilles & Jones bending roll, 10 h. p. motor.
3 6-in. Cleveland punches belted to a countershaft driven by a $7\frac{1}{2}$ h. p. motor.
1 6-ft. Hilles & Jones bending roll.
1 24-in. Long & Allstatter punch.

These two latter are belted to a countershaft driven by a $7\frac{1}{2}$ h. p. motor.

The machine shop equipment is mainly belt-driven by a 20 h. p. motor through a line shaft. There are four lathes of various sizes, one shaper, one universal milling machine, three different sizes of radial drills, one planer, one heavy duty motor-driven boring mill, one double-head bolt cutter, two pipe threading machines, a combination grinder, one wet grinder.

In the flange shop are:

1 180-ton 60-in. Wood hydraulic punch and shear.
1 130-ton 60-in. hydraulic sectional flanging machine.
1 1100 lb. Bement Niles steam hammer.
1 10-in. Long & Allstatter horizontal punch, $7\frac{1}{2}$ h. p. motor.
1 250 lb. Bement Niles steam hammer.

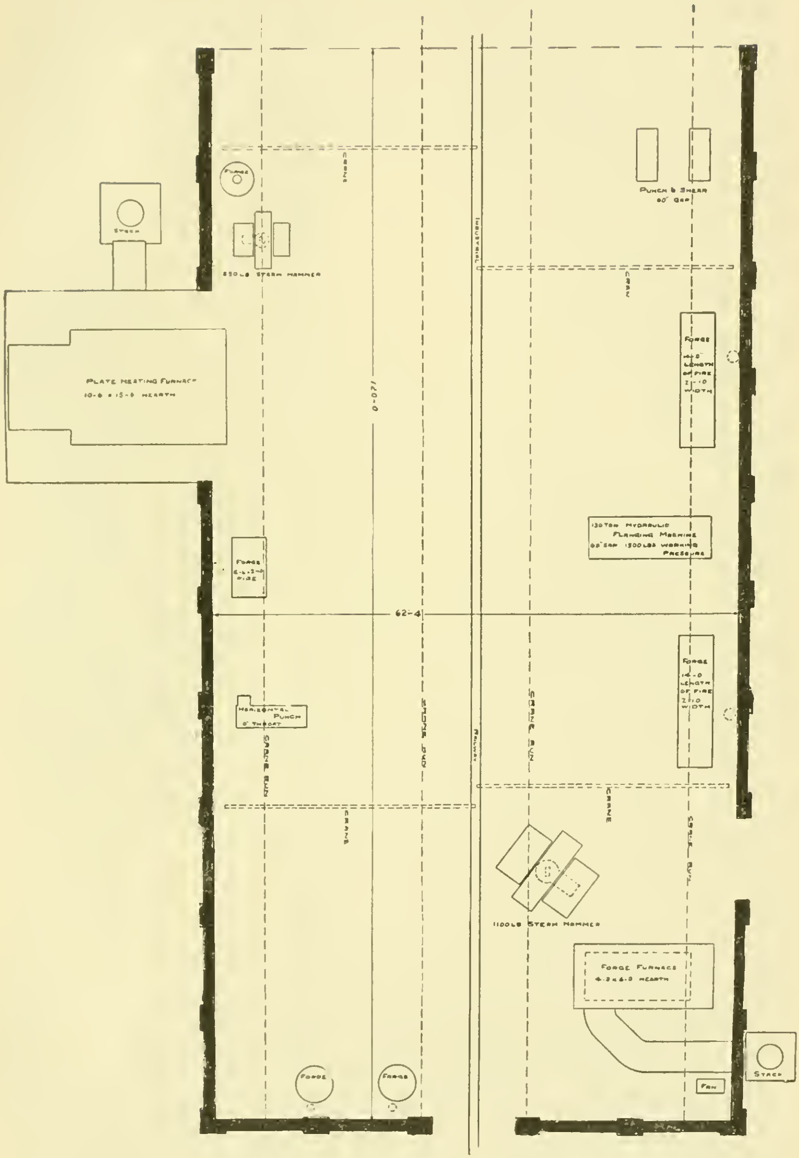


FIG. 4. PLAN OF FLANGE SHOP.
Showing arrangement of tools and cranes.

2 2 ft. 10 in. by 14 ft. hearth open forge fires.
1 2 ft. 10 in. by 6 ft. hearth open forge fire.
1 4 ft. 3 in. by 6 ft. hearth reverberatory forge furnace.
1 10 ft. 6 in. by 15 ft. 6 in. hearth reverberatory plate heating furnace.
3 blacksmith forges.
1 $24\frac{1}{2}$-in. motor-driven blast fan and pipe connections to forges.
1 cast-iron plate straightening bed and roller.
Complete set of cast-iron forming blocks, dies, etc., to suit the special requirements of the type of boiler built by this company.
4 3-ton Curtis traveling cranes.

All the small traveling cranes in both shops on adjacent parallel tracks overhang their runways far enough so they can be locked together and the trolley run from one to the other. (Fig. 4.)

All the steam, hydraulic and air pipes and electric wires are brought over from the power house in covered trenches and are so arranged that they can be easily drained in cold weather to avoid all danger of freezing. The air pipes have numerous connections at convenient points throughout the main shop, flange shop and machine shop.

Power House.

The boiler plant consists of three Heine boilers of 250 h. p. each, set separately. Two of them are provided with Heine superheaters of two different capacities. (Fig. 6.) They are all fired by hand and have flat shaking grates. Back of the bridge walls of each furnace is a special fire brick wing wall construction for the prevention of smoke, which accomplishes the object very satisfactorily. The two boilers with the superheaters are set in brickwork in much the usual way. The third boiler has a reinforced cement setting with fire brick lining. This was tried as an experiment to determine the availability of concrete construction for this purpose, and with the expectation that it will be more durable than brick and less liable to the cracking that all brick settings are subject to. The three boilers differ each from the others in dimensions, and all are arranged so that measurements and observations of all kinds may be conveniently made.

The company has in view a great variety of experiments to determine questions now in doubt and to develop further improvements in boiler practice. This will account for the boiler capacity being greatly out of proportion to the rest of the

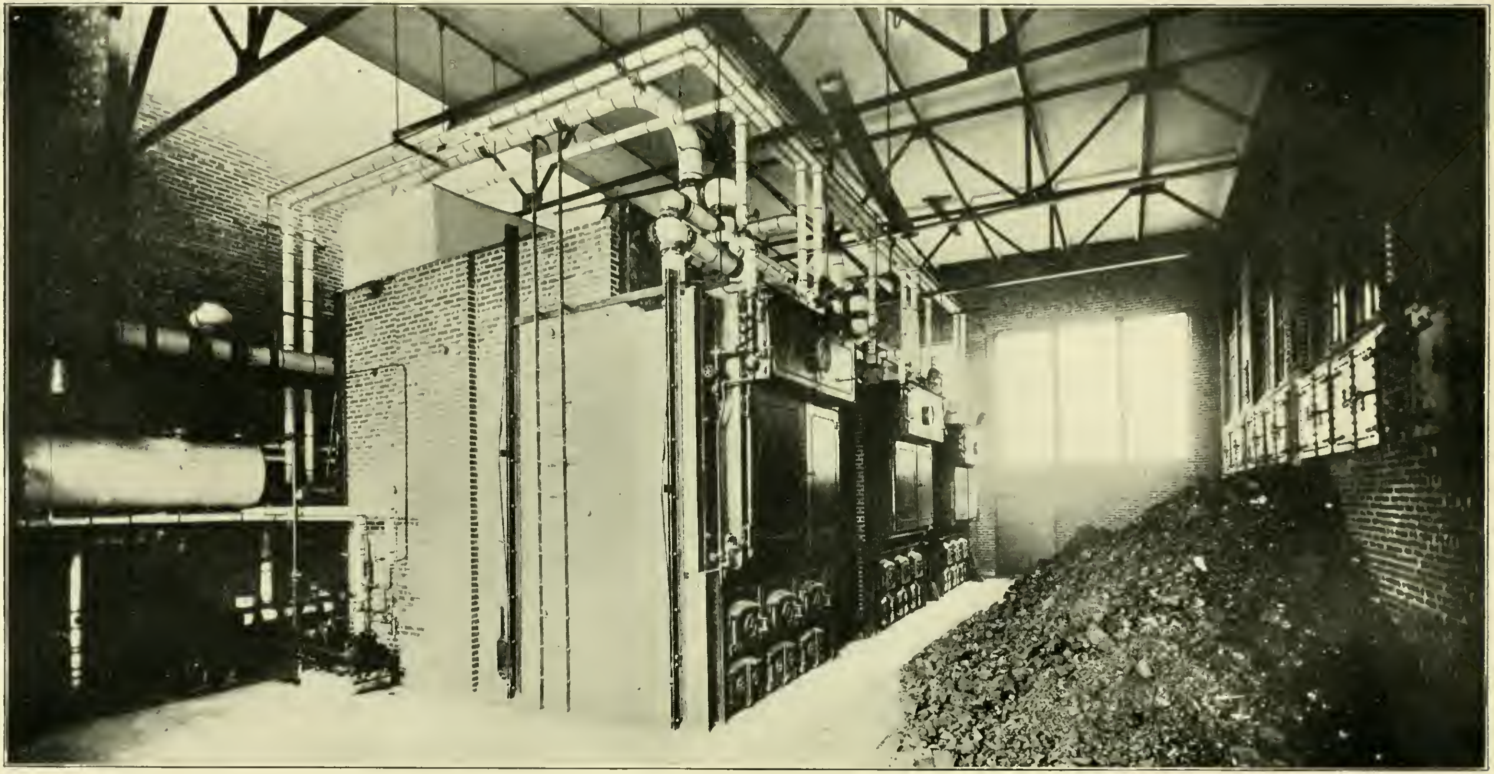


FIG. 6.

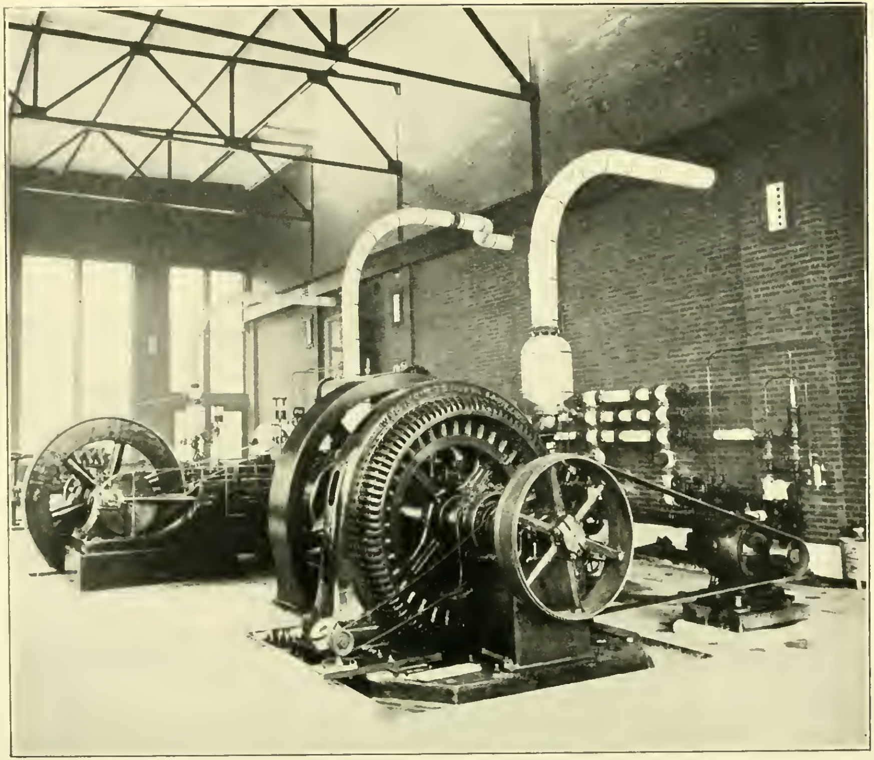


FIG. 7.

plant; one boiler will easily carry the load. A straight horizontal sheet-iron breeching connects the boilers with the chimney located in the space between the boiler house and the flange shop. This is a reinforced cement chimney 66 in. inside diameter by 147 ft. high, the foundation for which is 11 ft. deep and 22 ft. square at the base, a concrete monolith.

As the power requirements are not great, the installation of automatic stokers and coal and ash handling machinery was not deemed expedient. Coal is, therefore, unloaded by hand into the space in front of the boilers, which has a capacity of about two cars.

A Hoppes exhaust steam feed water heater, with a capacity of 15 000 lb. of water per hour, is placed on an iron support against the division wall. The air supply for the compressor is brought from the roof through a 12-in. sheet iron duct to an air washer placed behind the boilers. A small duplex steam pump delivers water from the cistern to the heater, being regulated by a Fisher governor. A boiler tester of the injector type supplies hot water under the required pressure for the hydrostatic test applied to all boilers before shipment. This testing can also be done by pressure from the hydraulic system, and through proper connections by the boiler feed pumps. An injector for feeding the boilers is provided for the use of the night watchman in order to avoid running the pumps.

All hot piping and the smoke flue are heavily covered with 2-in., 85 per cent. magnesium covering. Two openings 3 ft. wide and 7 ft. high are the only inside communications between the boiler and engine room and are closed by sliding wooden doors covered with sheet iron. One end of the boiler room serves as a workshop and has an enclosed dressing room and toilet.

The electrical energy is developed by a 162 h. p. 4-valve non-condensing Ball engine, 13 in. by 18 in., running 200 rev. per min. A 100 kw. 220-volt 3-phase 60-cycle Western Electric Company's generator is directly connected to the engine. An 11-kw. exciter is belted to a pulley on the engine shaft. The voltage is maintained constant by a Tirrell regulator mounted on the switchboard. All wires in the engine room are placed in conduits under the floor. The switchboard is completely equipped with all the measuring, controlling and distributing devices, and is divided into four panels, one for the generator, all current delivered being measured by a watt meter, two for the four power circuits, one for the six lighting circuits.

A Laidlow Dunn Gordon two-stage, compound, non-con-

densing air compressor is next to the engine. It has $12\frac{1}{2}$-in. and 22-in. steam and $22\frac{1}{2}$-in. and 14-in. air cylinders, with 18-in. stroke. Its capacity is 1200 cu. ft. of free air per min. at 100 lb. pressure when running at 145 rev. per min. 145 lb. steam pressure. It takes its supply from the air washer just the other side of the partition and discharges into a receiving tank 36 in. by 10 ft. standing nearby.

A Worthington duplex compound non-condensing pumping engine, with 14-in. and 22-in. diameter steam and 4-in. diameter water cylinders, 18-in. stroke, supplies the hydraulic system. Its capacity is 100 gal. per min. against 1500 lb. pressure, with 145 lb. steam pressure. A Wood hydraulic accumulator, 12 in. diameter of ram and 15 ft. stroke, loaded to give 1500 lb. pressure per sq. in., is located in one corner of the room. It is connected with an automatic controlling valve which shuts off the pump when the limit of lift is reached.

A 700 cu. ft. Norwalk air compressor, an old machine from the old shop, is located next the larger machine, and is connected to the same supply and discharge, but is intended only for emergency use. There is an additional space in the engine room for a duplicate generating set and also for another 1500 lb. hydraulic pump.

Two $7\frac{1}{2}$ in. by 4 in. by 6 in. Blake duplex outside packed plunger feed pumps are placed against the partition opposite the heater and are controlled by Fisher governors. (Fig. 7.) The feed piping is in duplicate and so arranged that any boiler can be fed independently of the others and of the other pump. This is to permit the testing of any boiler without interfering in any way with the operation of the plant. The suctions of these pumps are connected to the heater, the city mains and the cistern. Means are provided for filling boilers directly with city water. The small pumps have a separate steam header so as to be independent of the main steam header.

A 10-ton Pawling & Harnischfeger hand-power traveling crane, with $33\frac{1}{2}$ ft. span and $17\frac{1}{2}$ ft. lift, serves the entire area of the engine room. Only the live steam pipes are exposed in this room, all others being laid in covered trenches.

Miscellaneous.

Artificial lighting is mainly by 10 flaming arc lights uniformly distributed through the shops. They are hung to clear the cranes in monitor and bays and in the latter are about 22 ft. from the ground. The engine and boiler room have each one

lamp of the same kind. In addition, each machine tool has one or more incandescent lights near the workman. Special six-light incandescent fixtures are recessed in the walls 10 ft. from the floor around the sides of both engine and boiler rooms, with switches in closed hand high pockets. The water and steam gage of the boilers each has a light on separate circuits for each boiler. No outside current is used for either lights or power, except for two arc lights for night use and for the office.

A boiler shop requires heating only in comparatively cold weather, say when the temperature falls below 45 degrees fahr. It is, therefore, unnecessary to heat it above that temperature at any time. Open salamanders, usually without means for carrying off the gases of combustion, is the plan most often used, but a better plan from every point of view has been here adopted. The main shop is provided with a sort of hot blast system, consisting of five sets of enclosed coils of ¾-in. pipe, each containing about 3000 sq. ft. of radiating surface. A motor-driven fan forces the air through the coils, discharging directly into the room in an opposite direction from the intake. These sets are distributed so as to give the greatest heating effect where needed. It is anticipated that the circulation thus created will be sufficient to make the temperature sufficiently high and as nearly uniform as is necessary. Exhaust steam is used, but whether there will be sufficient or not, and whether the system will be satisfactory, has yet to be determined. The machine shop, toilet house and office are heated by direct radiators. The flange shop needs no special heating, the fires there being ample. If there proves to be insufficient exhaust steam, live steam will be turned in through a reducing valve, provision for this having been made.

To provide cool drinking water in summer a special drinking fountain was designed, of which two are installed. This consists of a concrete-lined pit about 4 ft. by 6 ft. by 3 ft. deep, divided into two compartments, one 27 in. by 27 in., the other 18 in. by 37 in. The walls of the larger, which is the ice chamber, are built with air spaces. Near the bottom is a horizontal coil of 1¼ in. galvanized pipe, with a wooden grating above to hold the ice. A drain, the bottom of which is 2 in. above the top of the coil, carries the warm water into the other compartment, in which are the valves for shutting off the supply, etc., and from which all waste is drained into the drainage system leading into the cistern. Over this latter compartment is the hydrant, with a suitable waste pipe and perforated cover. About 300 lb. of ice

can be put in the chamber, which is covered with both a thick wooden and an iron lid. In hot weather the supply of ice lasts two days. Water from the city mains is used exclusively for drinking.

Although the buildings are free from fire risk to such an extent that it is considered unnecessary to carry insurance, there is more or less inflammable material around in the shape of boxes, barrels and other packing material, as well as wooden railway cars. A simple fire system was, therefore, installed. Six 2-in. fire hydrants are uniformly distributed through the main shop, with 100 ft. of canvas hose and nozzle suspended on holders at each. There are also three hydrants outside, two on the opposite sides of the front end of the main building and one near the oil house. The water supply is from the city mains and under a pressure of 60 lb., so no other source of supply for this purpose is necessary. In addition, there are nine Minamax non-freezing and twenty-four Johns-Manville dry powder fire extinguishers hung at numerous convenient points. This is supplemented by a city fire-alarm box on the outside of the power house.

Costs.

The land was purchased in the middle of 1907 and the general scheme worked out by the officers of the company in conjunction with Messrs. Lichter & Jens, consulting engineers, who drew the plans and superintended the work. Much of the preparatory drafting work was done prior to the time when the decision was reached to proceed with the building of the plant.

The actual construction was purposely undertaken at a time of business depression. So far as prospects for obtaining sufficient orders to anywhere nearly develop the capacity of the plant when completed, or soon thereafter, were concerned, there was little incentive to proceed. Owing, however, to the very limited building operations of this nature throughout the country at the time, it was certain that the first cost would be very low. Early in 1908, when materials were at their lowest prices, it was, therefore, determined to proceed, financial arrangements having been satisfactorily concluded.

The grading was done in June and July, 1908. A little more than 18·000 cu. yd. of earth was excavated at a cost of 16 cents per yard.

This and the retaining walls were executed by the Fruin-Colnon Contracting Company.

The steel work, amounting to about 790 tons, was furnished

by the Riter Conley Manufacturing Company at the rate of practically 2.6 cents per pound f. o. b. St. Louis. It was all inspected by the R. W. Hunt Bureau of Inspections and Tests before leaving the factory.

The erecting of the steel was done by the Midland Erection Company at the rate of $8.80 per ton. The general contract for the completion of the main shop, flange shop and power house was executed by the Fruin-Colnon Contracting Company.

The total cost of these buildings was $1.15 per square foot of floor area, excluding the retaining walls and grading, and $1.29 including those two items. This, of course, does not include any of the equipment.

[NOTE. — Discussion of this paper is invited, to be received by Fred Brooks, Secretary, 31 Milk Street, Boston, by March 15, 1910, for publication in a subsequent number of the JOURNAL.]

BOYLSTON STREET BRIDGE, BOSTON, FROM 1888 TO THE PRESENT TIME.

THE DESTRUCTION AND RECONSTRUCTION OF A BRIDGE SUBJECTED TO LOCOMOTIVE FUMES AND INCREASING STREET CAR LOADS.

By Frederic H. Fay, Charles M. Spofford and John C. Moses, Members Boston Society of Civil Engineers.

[Read before the Society, December 16, 1908.]

Introduction.

By Mr. Fay.

An account of the Boylston Street Bridge comprises the life history of a metal structure over a railroad, built partly of steel and partly of wrought iron, which in less than twenty years was practically destroyed, that is, rendered unsafe for further use, through the following causes:

(1) The corrosive effects of locomotive fumes.

(2) The increase in weight of street cars.

(3) Neglect to properly care for those parts of the structure most exposed to the destructive action of locomotive gases.

The fumes from locomotives are primarily responsible for the destruction of the bridge. If the structure had been over water, it is probable that, with a proper strengthening of the floor system, it would to-day be standing and safely carrying the increased loads, although with 50-ton street cars like those now in use on the Boston and Worcester line the limiting load for the original trusses would have been exceeded, and restriction of car travel would have been necessary.

The destruction of the floor system of the bridge was hastened by the increase in weight of street cars which crossed the structure upon two tracks in the middle of the roadway. The floor beams, designed before the advent of electric cars, were built to provide for a live highway loading of 80 lb. per square foot or a single 20-ton wagon. In their weakened condition these beams had to carry not only the usual highway traffic, but also cars up to 26 tons weight on both tracks. In many instances under this car loading the floor beams, which were double-webbed plate girders, had their top flanges and even a diaphragm connecting the two webs broken; and while the rusted floor beam, if un-

broken, might have carried ordinary travel for some years more, these broken beams had become unsafe for heavy teaming and positively dangerous for further use by the street cars then crossing the bridge.

Improper maintenance, that is, neglect to properly clean and paint the structure, no doubt hastened its destruction to some extent. As is usually the case, the metal work exposed to view above the floor, which didn't need the care, was kept well painted, while that beneath the floor surface was rarely or never touched, and in the struggle between the locomotive gases and the paint, the gases had the field practically to themselves after the original paint coating had been once broken through.

The history of the first Boylston Street Bridge forcibly illustrates the fact that in metal bridges over railroads in which parts of the metal structure, protected only by paint, are underneath the floor, it is practically impossible to properly inspect or maintain the structure except by completely removing the floor surfacing, thereby rendering all parts of the metal work accessible for cleaning, examination and painting.

To-day we have at the Boylston Street crossing two structures, one within the other: one to carry the loads upon the car tracks; the other to take the loads upon the sides of the roadway and the two sidewalks; both structures built with a view to permanency by having a minimum amount of metal work below the floor and that protected from the locomotive gases, so far as possible, by concrete.

In the following papers there will be given an outline of the construction and history of the original bridge and a description of the structures built by the Boston Elevated Railway Company and the city of Boston to replace it.

Description of the Original Bridge.

By Mr. Fay.

Boylston Street crosses the main line of the Boston & Albany Railroad at the extremely sharp skew of 71 degrees; that is, the angle made between the center line of the street and the railroad location line is only 19 degrees; and while the location is but 60 ft. wide, the distance across the location, measured along the center line of the street, is 176 ft., or nearly three times the width of the location. The street is 80 ft. wide.

When the first Boylston Street Bridge was built, in 1888, no part of the railroad location was available for piers or for erecting

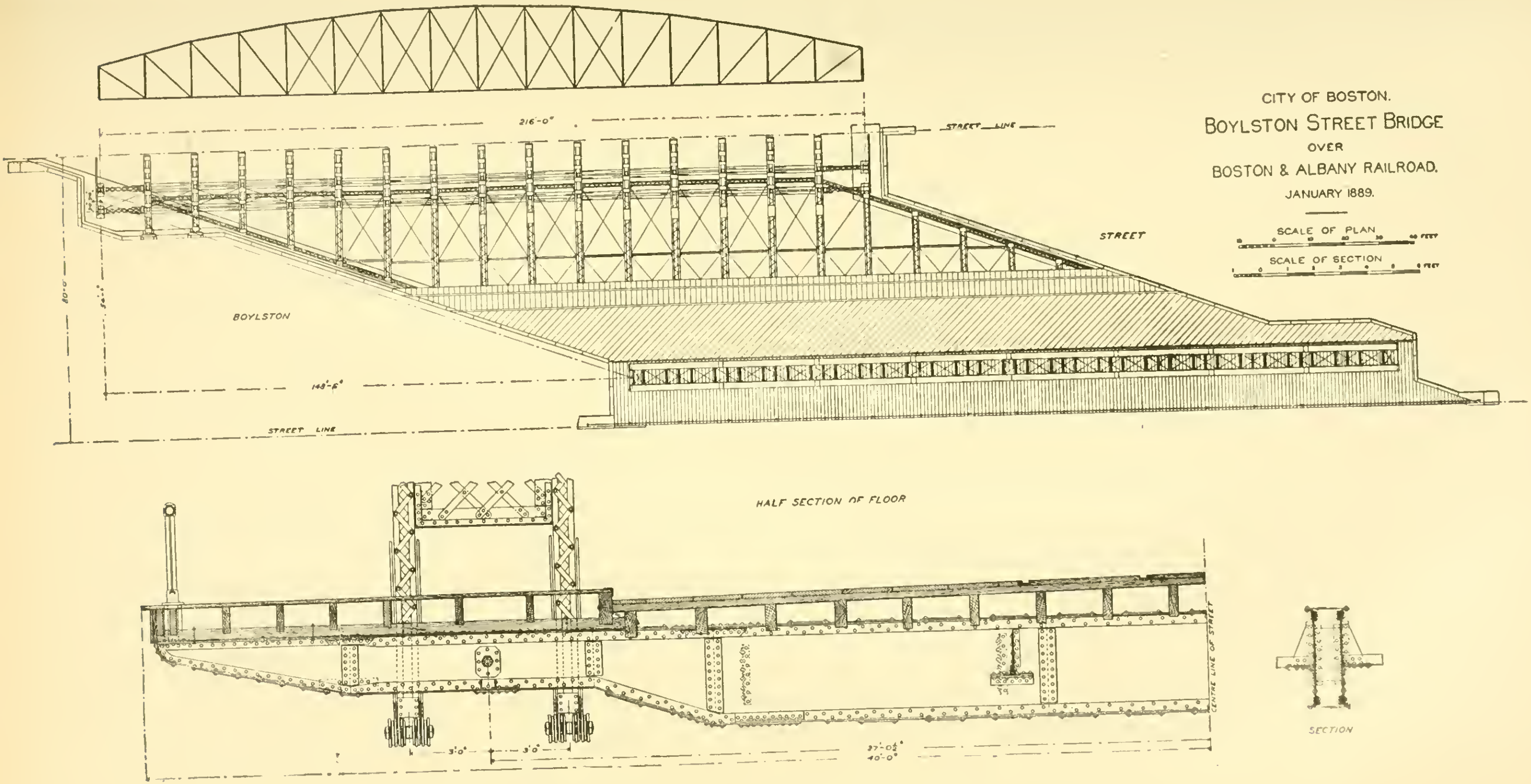


FIG. 1. GENERAL PLAN AND FLOOR SECTION OF ORIGINAL BRIDGE.

falsework, and it was necessary to make the bridge in one span and to provide for its erection by other than usual means. Furthermore, the extreme skew, the width of the street and the omission of a truss on the center line of the street prohibited the use of top lateral bracing. The problem was solved by the late John E. Cheney, then the assistant city engineer of Boston, who designed the structure with two double pin-connected pony trusses of 216-ft. span. Each half of the double truss was in reality a complete truss; and the two parts, placed 6 ft. apart on centers, were so connected together as to constitute a structure rigid in itself, requiring no outside bracing for its support. The design was notable in being one of the longest pony-truss spans in existence. The span of 216 ft. was divided into 16 panels of 13 ft. 6 in. each; the depths of truss varied from 9 ft. 4 in. at the ends to 24 ft. at the middle, the top chord being curved and the bottom chord straight. (See Fig. 1.)

The floor beams were double plate girders tied together on the top and bottom flanges by latticing and tie plates and having the webs connected at intervals by diaphragms. The floor beams extended beyond the trusses, forming brackets for the support of the sidewalks. The connections of the floor beams to the trusses were so designed as to distribute the loads from the beams equally to the two halves of each main truss, and were made by pins passing through the beams and through small girders connecting the double posts of the trusses. The principal floor beams were nearly 80 ft. long over all and had a span between supporting pins equal to the distance apart of the main trusses, center to center, viz., 54 ft. 1 in. The depth of these principal beams back to back of angles was 3 ft. 8 in. On account of the skew, most of the floor beams were placed with one end on an abutment, some of these beams being so short as to require anchorage to the abutment masonry.

All stringers were of hard or yellow pine; the lower course of roadway planking was 3-in. hard pine; the roadway wearing surface was 2-in. spruce; and the sidewalk plank was $1\frac{1}{2}$-in. hard pine.

In the trusses of the original bridge steel was used for main members for the first time in any bridge built by the city of Boston. The top chords, end posts, all eye-bars 4 in. wide and over, chord pins and rollers were made of Bessemer steel. All other parts of the trusses, the entire floor system and the bottom lateral bracing were made of wrought iron.

The requirements for the steel as determined from standard

test specimens were: Tensile strength, 62 000 lb. to 70 000 lb. per square inch; elastic limit, not less than 35 000 lb. per square inch; elongation in 8 in., not less than 22 per cent.; and reduction of area, not less than 45 per cent.; these requirements being substantially equal to those of the present day for medium steel. The specifications permitted the use of either Bessemer or open-hearth steel, and a high grade Bessemer steel was supplied by the mills of Carnegie, Phipps & Co., of Pittsburg, Pa. The steel eye-bars were manufactured by the Edge Moor Iron Company, of Wilmington, Del.

Full-sized tests of four of the steel eye-bars were made with satisfactory results, the details of the tests being given below.

Size of Bar.	5 x 1.	6 x 1.	6 x 1½.	4 x ¾.
Length, back to back, of pin holes, feet	13.89	13.89	13.89	27.5
Elastic limit, pounds per square inch	44 390.	36 460.	36 520.	38 210.
Tensile strength, pounds per square inch	65 110.	61 870.	58 770.	62 420.
Elongation, per cent. in 12 ft. ...	18.1	19.	14.9	...
Elongation, per cent. in 26 ft. ...	...	...	...	13.
Reduction of area at fracture, per cent	46.	49.4	50.	55.

The bridge was designed to carry the following live load:

Sidewalk: 100 lb. per square foot from fence to center line of double truss.
Roadway: 80 lb. per square foot from center to center of double truss (54 ft. width), also a single 20-ton wagon.

Although the bridge was designed for a live load covering every square foot of its floor surface, including the floor surfacing at the trusses, it is to be noted that the trusses practically excluded live load from a strip 8 ft. wide at each sidewalk.

The unit stresses allowed were the following, no allowance being made for impact:

Steel: Tension on Bessemer eye-bars..............17 500 lb. per sq. in.
Compression base unit for column formula...13 333 lb. per sq. in.
Wrought Iron: Allowable tension ....12 000 lb. per sq. in.

It will be seen that great confidence was placed in the ability of the Bessemer steel eye-bars to withstand tension, the tensile unit of 17 500 lb. per square inch (without impact allowance) being considerably higher than that now commonly used for open-hearth medium steel. In steel compression members, however, the conservative practice was followed of using for the

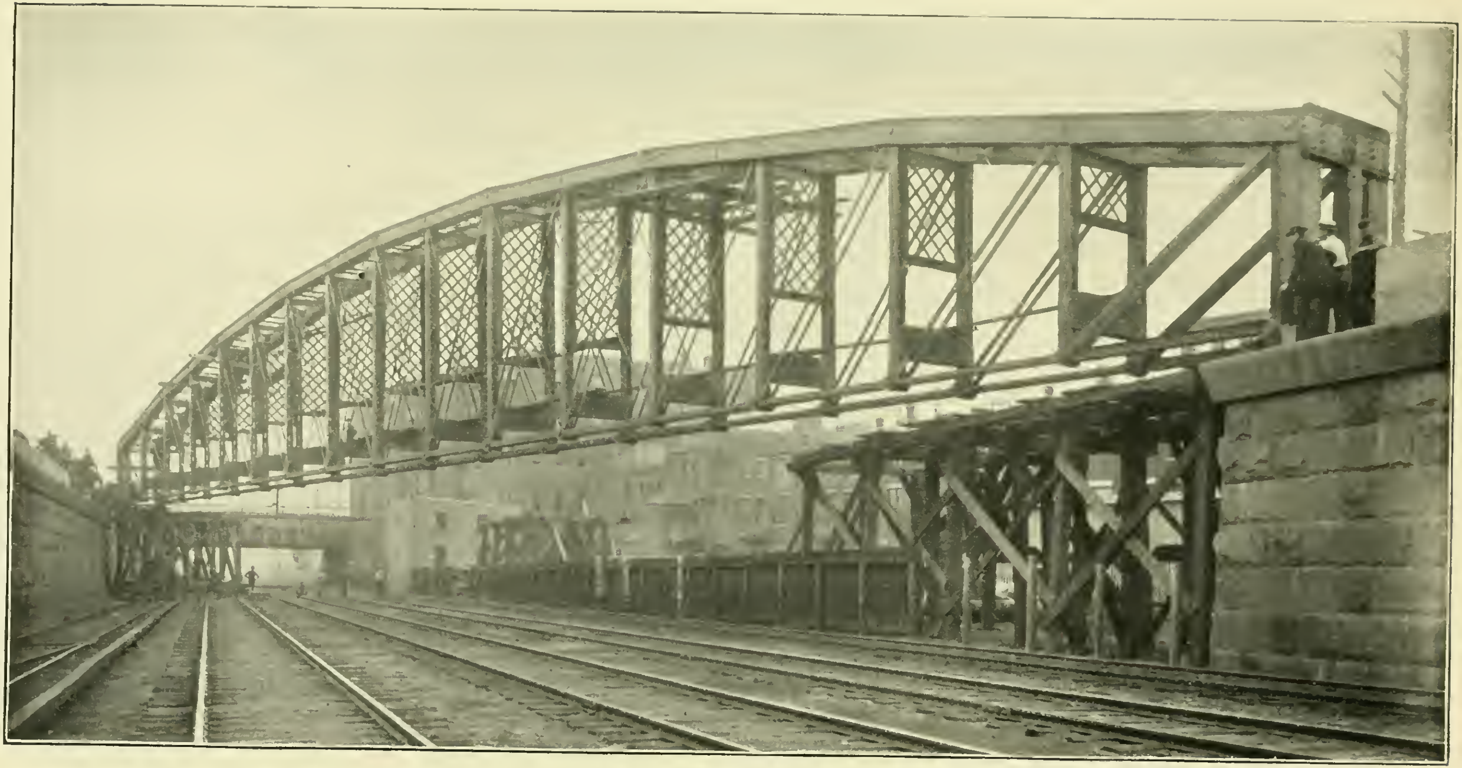


Fig. 2. Swinging Trusses of Original Bridge into Position across Tracks of Boston & Albany Railroad.

Fig. 27. General View of Bridge as Finally Reconstructed.

base unit of the column formula a compression unit considerably less than that allowed in tension. In the top chords of the trusses the maximum actual compression unit under full load was less than 13 000 lb. per square inch.

Measured by the standards commonly accepted by engineers just prior to the Quebec Bridge accident, one would say that in the original Boylston Street trusses the top chord was considerably stronger than the tension members of the truss, although from what has been learned since the disaster of 1907 it is probable that in actual strength the top chord was not so much stronger than the eye-bars as one might have thought. However, as it was in the eye-bars that the worst corrosion of the trusses occurred, while the top chords, which had been kept well painted and nearly free from gases, were practically as good as new after nineteen years' service, the top chords then were retained and used in the reconstruction of the bridge just carried out, while the remainder of the trusses found their way to the scrap heap.

The general design and detailed drawings for the bridge were prepared by the engineering department of the city of Boston under Mr. Cheney's direction. The construction of the bridge superstructure was let to the Boston Bridge Works, the price paid under the contract being $46 490.90.

An account of the erection of the trusses of the bridge will be found in the Twenty-Second Annual Report of the City Engineer of Boston (for 1888) as follows:

"Several methods of putting the main trusses of the bridge in place, without the use of falseworks in the railroad location, were considered, but the railroad officials having consented to allow their tracks to be occupied by movable falseworks for a few hours on Sunday mornings, the contractor was enabled to carry out the plan devised and preferred by him.

"Each truss was erected on a staging at the side of, and parallel to, the railroad, one end of the truss resting on an abutment and the other end on a timber horse or tower. Between the truss shoes and the top of the tower were placed iron rollers, working between bars of railroad iron, and underneath the tower were wooden rollers resting on timber sills.

"When the truss was connected, its abutment end was placed upon an hydraulic jack and the tower end swung about this jack as a pivot to the opposite abutment, the tower moving, by means of the wooden rolls, on sills laid across the railroad tracks. (See Fig. 2.)

"When the tower had reached the abutment, the top of the tower was adjusted to the proper level by means of jacks, and the end of the truss moved on the iron rolls and railroad iron from the tower to its proper place on the abutment.

"The trusses were swung into place on the mornings of July 22 and 29, 1888, respectively, about four hours being taken each morning for doing the work, including time spent in waiting for the arrival and passage of trains on the tracks crossed."

Design of the Street Railway Bridge.

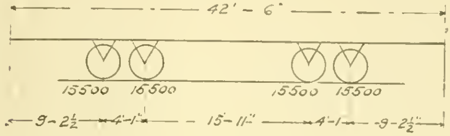
By Professor Spofford.

The writer's connection with this bridge began in June, 1906, when he was engaged by the Boston Elevated Railway Company to examine and report upon certain Boston bridges across which it was desired to operate heavier cars than those previously used. The instructions originally given were to report upon the safety of these bridges under the 50-ton and 42-ton cars shown in the following diagrams, in which are included, for comparison, the weights of the heaviest cars now operated in New York City, the data for which were furnished the speaker by Mr. Henry W. Hodge, of the firm of Boller & Hodge, consulting engineers, of New York. (See Fig. 3.) Of the bridges investigated, the bridge under discussion was found to be the only one presenting a serious problem, though of the other bridges, one or two required some strengthening, and one, the Huntington Avenue Bridge across the Boston & Albany Railroad, was known to be in such a seriously corroded condition as to render it dangerous to operate heavier cars than those already in use, and impossible to permanently strengthen without entire reconstruction.

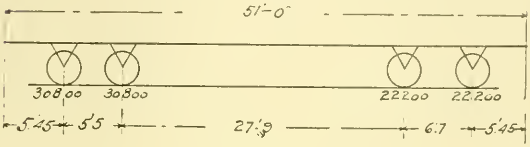
Computations quickly showed the floor system of the Boylston Street Bridge to be unsafe for the new loads, regardless of the corrosion which had occurred, and reconstruction was surely necessary. A computation of the truss stresses which the heavy cars would produce showed these to be highest in certain members of the bottom chord in which the stresses, even on the assumption that no loss from corrosion had taken place, were found to be too high for the Bessemer steel of which the bridge was built, a material treacherous at the best and long ago discarded for important structures where life and death are in the balance. A cursory examination from the ground below showed furthermore that considerable corrosion had occurred. This was anticipated as the location of the bridge between storage yards and round houses, with locomotives passing almost continually and frequently standing under the structure, seemed especially bad. A careful examination was, therefore, made by means of ladders erected on the railroad location and protected by flagmen under the direction of the section foreman. These ladders were fur-

Fig. 3.

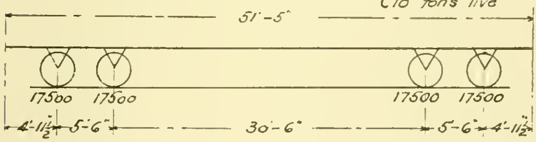
BROOKLYN RAPID TRANSIT TROLLEY-CAR.
Type 1300 – 1907 – 31 Tons Loaded



LONG ISLAND R.R. STEEL MOTOR CAR
1907 – 53 Tons Loaded
(In use on Broadway Elevated R.R., BROOKLYN.)

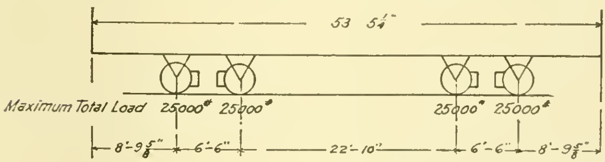


INTERBOROUGH SUBWAY TRAILER-CAR.
Steel – 1908 – 35 tons loaded {25 tons dead, 10 tons live}



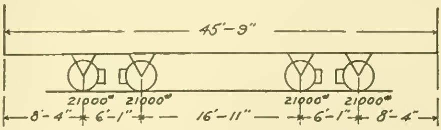
Each of the above is the heaviest car of its type in use in Greater New York in December, 1908.

50-TON BOSTON AND WORCESTER STREET RAILWAY CAR.



B.E.R'y., Sketch L.B. 90/434, Feb. 15, 1906.

BOSTON ELEVATED RAILWAY CO. 42-TON TUNNEL CAR.



Weight unloaded,	63,350.	B. E. Ry. Sketch D. 3218, revised to March 22, 1907.
Maximum load,	20,800.	
Total,	84,150.	

nished and operated by one of the street railway emergency gangs, and during this examination the writer was accompanied by representatives from the city engineer's office.

The most serious corrosion discovered at this time was in the bottom flanges of the floor beams where the outstanding angle legs were seriously reduced in size, and the lattice bars used to connect the two halves of the double floor beams were in one case found to be entirely eaten away, and in other cases so reduced that they were easily broken by a single blow of a light hammer. The bottom chord eye-bars were also considerably corroded, but their thickness was considerable and the percentage of reduction was consequently not especially large, though their section was so reduced as to render it unsafe in the writer's opinion to permit unrestricted operation of the proposed new cars. In the examination, no evidence was seen of serious corrosion of the diagonals at the floor level, nor was there any suspicion in the writer's mind nor in the mind of the representatives of the city that the corrosion at that level would be materially greater than that lower down and more directly subject to the blast action from the stack, the force of which was quite evident during the examination. Moreover, these diagonals were not stressed as high as the bottom chord and in many panels had considerable excess section because of the impossibility of getting bars small enough to give just the right area. In view of the condition actually found to exist when the bridge was stripped and the bars cleaned, the writer regrets that he did not carry out his half-formed intention to strip the flooring and examine the truss from above, rather than from ladders below, which would have been less dangerous and, in the light of the facts disclosed, more satisfactory. It is the writer's belief that this serious corrosion at the floor level was due to the wooden floor proving sufficiently tight to restrain the locomotive fumes and keep almost constantly in place at that level a thin film of corrosive gases.

Because of the high stresses and deteriorated condition, it was reported to the railroad that the floor system must be reconstructed at all events, and that the trusses would need to be strengthened to permit unrestricted operation of the cars proposed, although it was suggested that the operation of the cars might be limited in such a manner as not to seriously overstrain the trusses. The restriction of traffic by requiring a certain distance to be maintained between cars did not meet the approval of the operating department of the railway, although attention

may be called to the fact that the enormously heavy surface-car traffic across the Brooklyn Bridge has been controlled in this way for years, and that the congestion of traffic on this bridge is apparently in no way due to this cause, but is brought about by terminal conditions. After considerable deliberation it was finally decided to proceed with the complete strengthening along the lines suggested by the writer, who was authorized to prepare the necessary plans. Several schemes for this strengthening appeared possible and are enumerated below.

First. The complete removal of the existing floor system and the swinging of the trusses to a position parallel to the railroad track where they could be supported by sub-falsework which could not be constructed with the bridge in position; the removal of pins, the addition of longer and, where necessary, larger diameter pins; the erection of additional eye-bars, and of other members where necessary; and, finally, the swinging of trusses into position again and construction of a new floor system.

Second. The erection of temporary trusses to sustain the old structure and the addition of new pins, bars and floor system as in the first method.

Third. The erection of a center truss, together with the changes necessary in the floor system to make the latter strong enough when supported by the center truss.

Fourth. The erection of a new truss on each side between the old trusses and connected rigidly to them, and the construction of a new floor system to carry the Elevated Railway traffic.

Fifth. The erection of new trusses as above, supported laterally, but not vertically, by the old trusses, and the construction of a new floor system to be supported by the new trusses and to carry the street railway traffic only.

Of these methods, the first two seemed unnecessarily expensive, and the first, moreover, would result in entire stoppage of traffic for a considerable time. The third would decrease the roadway clearance considerably, would require overhead bracing for lateral stiffness, which the sharp skew and limited headroom prohibited, or else new double trusses of considerable width, which would reduce the clearance too much. Such center trusses would also be heavy, as they would have to carry much more than one track load.

The fourth and fifth methods could be carried out without cutting off all traffic, would be economical of material, would make the bridge safe for the railroad traffic, regardless of the con-

dition of the old trusses, and would afford the opportunity to strengthen still further the old trusses wherever that might be necessary without additional support by falsework or otherwise.

A superficial consideration of the fourth and fifth plans would perhaps give the impression that the fifth would require more material. This is, however, incorrect as the addition of new material to an old structure without supporting the latter on falsework is uneconomical since the new material will not relieve the old of its dead stress and will carry only a portion of the live stress. The lack of economy of this method as compared with the addition of independent members is well illustrated by the following example:

Let the dead stress in a given bar	=	100 000 lb.
Let the original live stress	=	80 000 lb.
Let the original area	=	12 sq. in.

To strengthen the above bar by the addition of new material so that the unit stress under the same dead load and an additional live load of 120 000 lb. will not exceed 15 000 lb. per square inch requires the addition of 18 sq. in.* To carry this increased live stress by a new bar requires the addition of only 8 sq. in., or four ninths of the material needed for the first case.

In view of these reasons, the fifth method was adopted and plans made accordingly. As in all repair work, numerous difficulties were encountered, most of which were anticipated from the start. Among the more important of these may be mentioned the following:

The design of the intermediate posts of the new trusses to permit their erection between the old trusses without interference with either the transverse vertical bracing shown in Fig. 5, or the double floor beams of the old structure; the support of the new trusses laterally by means of the old structure without restricting the free vertical and longitudinal movement of either truss; the erection of the new floor system without shutting car travel from more than one track at a time, and without interfering with existing floor beams and lower laterals; the separation of the floor of the new bridge from that of the old so that both might deflect freely and at the same time have a continuous surface.

* This may be determined by the solution of the following equation in which A = new material required.

$$15\,000 = \frac{100\,000}{12} + \frac{200\,000}{12 + A}.$$

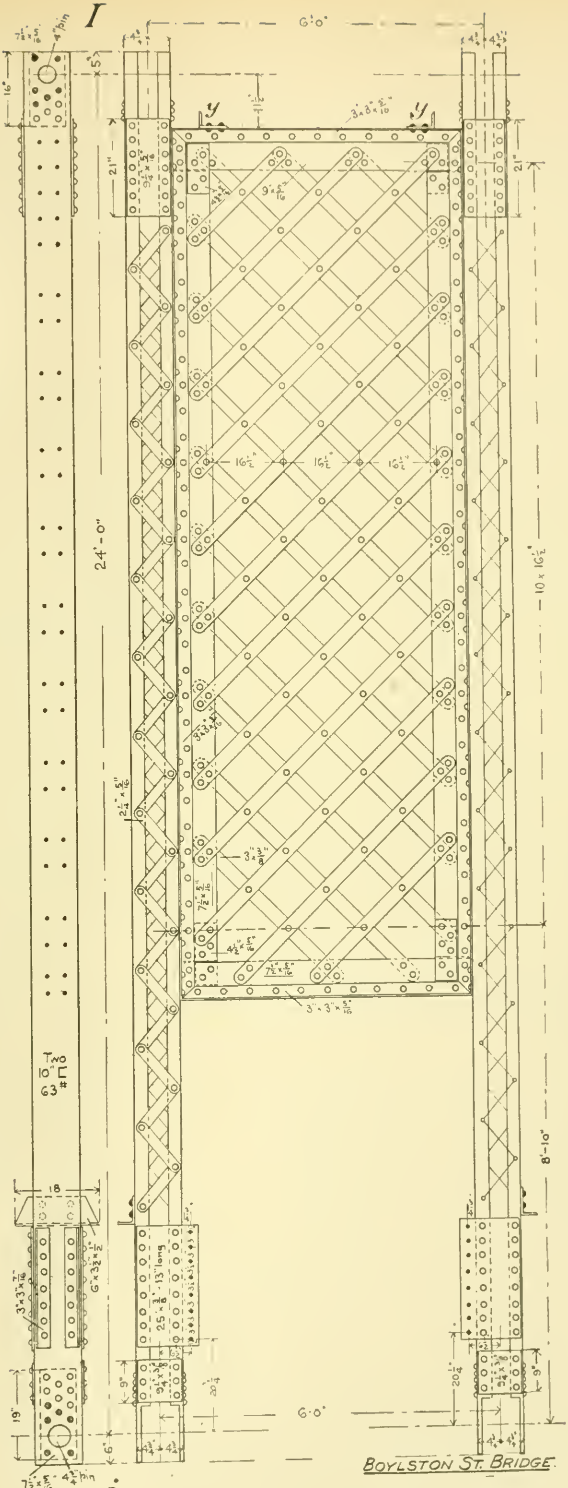


Fig. 5. Vertical Transverse Bracing between Original Trusses.

Fig. 4 shows the relation between the new and old work. Fig. 6 indicates the method adopted in solving the first of the above-mentioned problems. The intermediate posts were made in upper and lower sections, each of which was in halves, each half

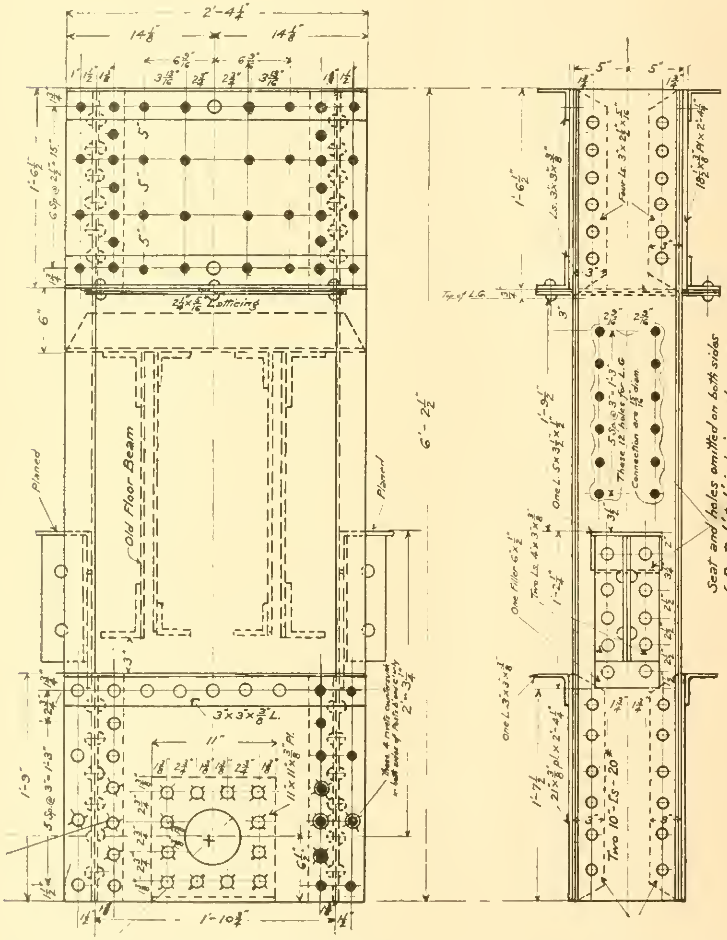


FIG. 6. RAILWAY TRUSSES. BOTTOM HALF OF AN INTERMEDIATE VERTICAL UPPER HALF TO BE RIVETED TO THIS HALF IN FIELD.

being made of sufficient strength to carry one half the load as an independent column. In this way the upper sections were made to straddle the transverse bracing shown in Fig. 5, and the lower sections the old floor beams shown dotted in Fig. 6. The division

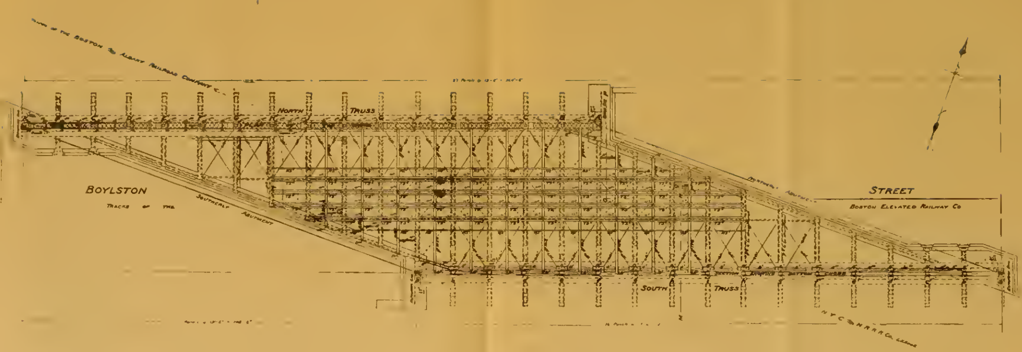


FIG. 4. GENERAL PLAN SHOWING RELATION BETWEEN ORIGINAL STRUCTURE AND RAILWAY STRUCTURE.

New material shown by full lines.
Old material shown by dotted lines.

the posts into upper and lower sections was made necessary by e inability to drive splice rivets and pins in the upper chord ıen the latter was in position between the chords of the old ucture. The upper chord, the upper post section and the upper rtions of the diagonals, which were all adjustable, were, there- e, erected with the top chord supported on the transverse acing between upper chords of the original trusses. After the per half of the truss was thus assembled this bracing was re- oved, temporary bracing provided in another position and the ıole upper section lowered until it could be connected with the ver portion which had previously been put into place.

The method of supporting the new truss laterally is indi- ed by Fig. 7. The horizontal ribs of the top chord struts own in the figure were passed through holes cut in the top ord ribs and of sufficient size to permit free vertical deflection. e vertical ribs were then riveted to these horizontal ribs, and ends of the strut thus formed riveted to the old trusses. The ıter portion was made so that it would be a close fit transversely the new top chord, but free to hold it vertically. The lateral ıcing previously removed from the plane of the top chords of old structure was then replaced, but was moved longitudi- ly so that the diagonals would clear the pins of the new chord. order to put this bracing into place it was necessary to cut es in the new top chord as shown in Fig. 7. The bottom the new truss was also supported laterally by means of guide gles riveted at both ends to the top flanges of the old floor ıms. These are shown in Fig. 6.

Interference between the new and old floor beams was pre- ıted by locating the new beams midway between the old ıms and consequently midway between panel points of the v trusses. Support for these floor beams was provided by gitudinal girders extending from panel point to panel point l lying in the plane of the new truss. These longitudinal ders were riveted at one end to the truss post, but the other end s bolted and the nuts were not screwed tight, the reaction being ried by a bracket. This arrangement was made in order that longitudinal might not prevent free action of the truss. The or beams were made in halves to permit erection without inter- ence with travel on more than one track at a time and were iced in the field at a point slightly removed from the center.

The method of procedure given in following plan of erection icates clearly the unusual character of the construction and difficulties to be overcome.

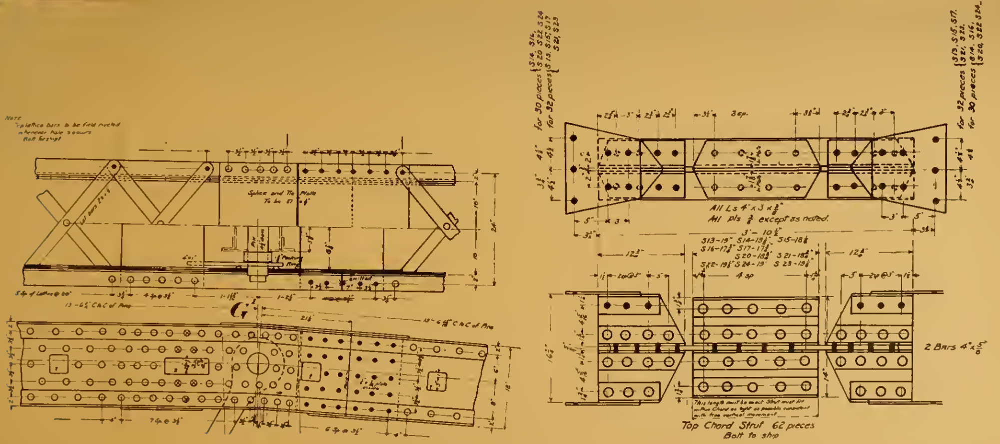


FIG. 7. RAILWAY TRUSSES. PORTION OF TOP CHORD AND TOP CHORD STRUTS.

Proposed Plan of Erection.

The new work shown by piece marks on this sheet and in detail on sheets 2–13, inclusive, dated October 30, 1906, has been designed in accordance with the following method of erection:

1. Close to traffic southerly sidewalk and roadway up to southerly car track.

2. Remove sufficient sheathing on southerly side of bridge to permit the removal and reconstruction of the existing bottom struts S^1, S^4 and S^5, shown on sheet No. 1 of original set of drawings dated January, 1888, and the erection of the bottom sections of the intermediate posts and diagonals, the end posts and shoes, the bottom chord and the longitudinal girders.

3. Cut out the struts S^1, S^4 and S^5, mentioned above, with the attached laterals, and reconstruct struts as shown on sheet No. 2 of 1906 set of drawings. Reconstruct also easterly end of abutment strut S. These struts and rods are to be removed from not more than two panels at once. Drill new rivet holes in existing floor beams for connection of these struts, replace struts in new position and add new laterals. Notch flanges of old floor beams where necessary to clear diagonals of new truss; drill also new holes in top flange of all existing floor beams to fit guide angles shown on sheet No. 2 of 1906 set of drawings.

4. Put into place at each panel point, while both adjoining struts are disconnected, the bottom section of the intermediate post, which is made in halves to facilitate erection, and should be riveted together at bottom before struts are riveted in new position, as otherwise it will be impossible to drive certain of the rivets. The bottom chord pin should be put into position before the two sections of the post are assembled, as it cannot be put in after the post section is in its final position. After assembling these sections of the bottom posts they should be temporarily supported on the existing floor beams, but should not be riveted at top until after the entire truss is assembled.

5. Put into position the longitudinal girders and bolt to posts, but do not rivet.

6. Assemble the bottom chord bars and bottom sections of intermediate diagonals. Note that these must be slipped over the ends of the pins, as pins will already be in place.

7. Remove bracing between top chords, replacing it by temporary bracing satisfactory to the city engineer.

8. Assemble top chord, end posts, end diagonals, top lateral bracing and top sections of intermediate posts and

diagonals. These are to be assembled at a height greater than final elevation, in order to permit the driving of splice rivets and pins, and are to be supported by blocking carried by the sway bracing between the existing trusses. Note that the intermediate posts are made in halves to facilitate erection.

9. After upper portion of southerly truss is completely assembled, remove end sidewalk brackets and lower the truss into its final position, support the end posts on blocking, bolt the intermediate posts together at splices and connect the bottom of the end diagonals to chord pin.

10. Rivet verticals at splices, connect adjustable diagonals and chords and rivet longitudinal girders at one end, bolting at other. Nuts on bolts are not to be screwed tight, as it is desirable to provide for $\frac{1}{8}$ in. play in girders. After nuts are on, hammer bolt threads sufficiently to prevent nuts working loose.

11. After truss is finally assembled, riveted and adjusted, jack up slightly at ends, remove temporary supports of post sections at floor beams, put into place rollers and fixed end bearings, lower truss into final position, rivet and adjust top bracing and rivet end portal plates and sidewalk brackets.

12. Strip remainder of sheathing on southerly roadway and car track and put southerly halves of floor beams into place temporarily, removing bottom bracing in one panel at a time. These floor beam sections may be temporarily supported at northerly end by fastening to existing floor beams. Reinforce also at this time the old floor beams, F^5 and F^6, at easterly end of bridge, and make whatever other slight changes are necessary in southerly halves of other floor beams.

13. Lay new permanent sheathing on southerly roadway and sidewalk; lay also temporary track stringers on southerly car track, supporting stringers in both cases on old floor beams, and using old stringers under car track and under roadway, where permitted by the city engineer.

14. In a similar manner erect northerly truss and floor beams, but in this case rivet floor beam sections together at splice before relaying sheathing and put into place the permanent track stringers in northerly track. Note that some of the splice rivets in top flange of F^{14} cannot be driven at this time, but must be driven when temporary southerly track is removed. All other splice rivets should, however, be driven.

15. Finally replace temporary track on southerly side.

The floor construction is shown in Fig. 8. The design of this to fulfill the conditions previously mentioned was somewhat

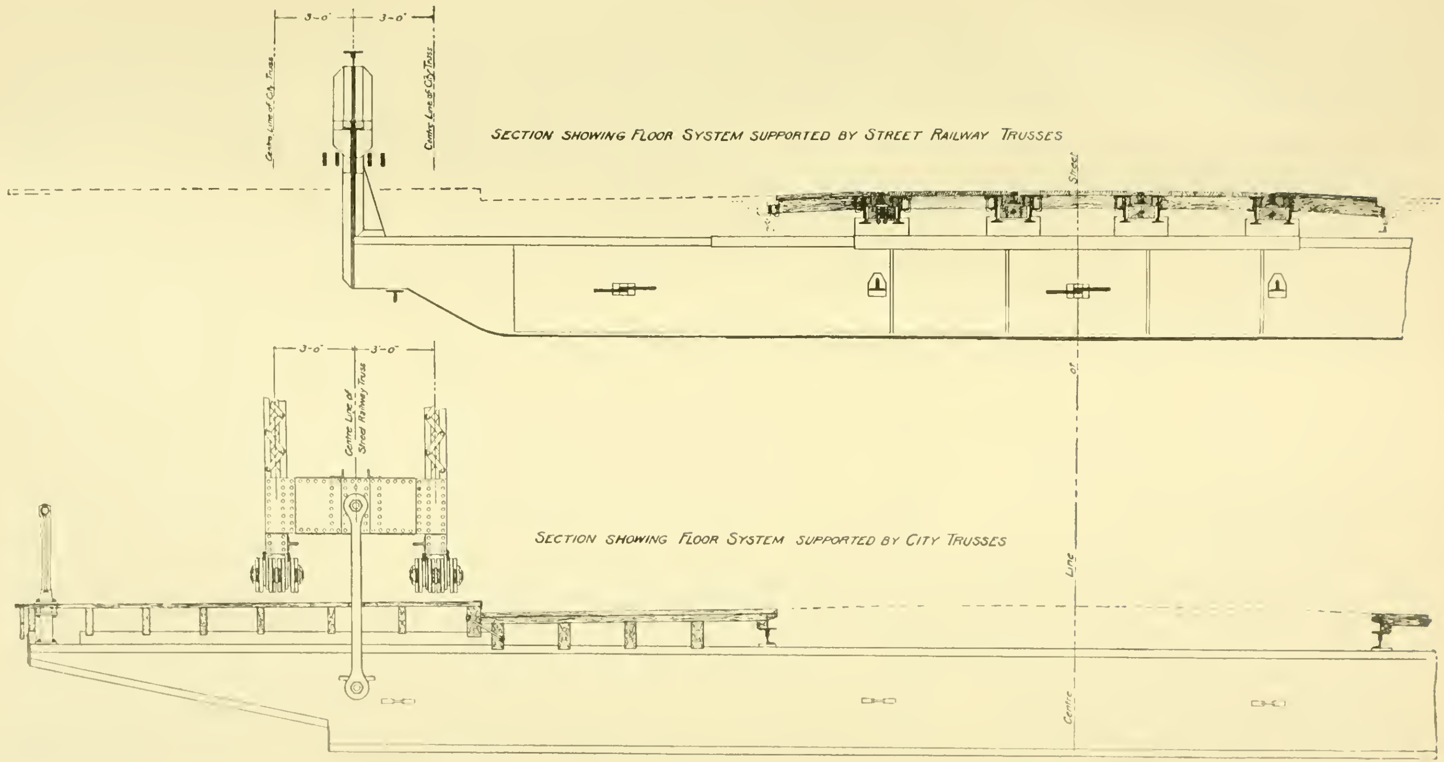


FIG. 8. CROSS SECTIONS OF BRIDGE FLOOR AS FINALLY REBUILT.

of a problem because of the very limited headroom. To prevent interference between the trusses it was necessary that the old stringers should clear the new floor beams, and the stringers of the new structure clear the old floor beams. It was also necessary to have a strip of flooring on either half of the bridge which should act like a hinge. To accomplish these results the new stringers were each made of two I-beams connected at the bottom at close intervals by $\frac{3}{4}$-in. plates, which, in turn, support hard pine rail seats of a height such that the top of rail is level with the floor surface. These stringers are supported on brackets placed on top of new floor beams and are stiffened by diaphragms placed at 4-ft. intervals. The floor timbers are supported on shelf angles riveted to the sides of the stringers. In order to construct the floor hinges mentioned the wooden roadway stringers of the old structure adjoining the rail stringers were replaced by channels and the section of the floor between these roadway stringers and the track stringers supported on shelf angles and bolted by hook bolts. The floor sheathing on these sections is laid lengthwise, and a little clearance left at the track stringers so that there will be no interference with the hinge action. This clearance is made as small as possible to prevent the accumulation of pebbles and dirt in the crack. In order that the floor timbers might be put into place the ends of these timbers were beveled and sufficient clearance provided between them to permit the insertion of the end timber in a panel when the others were bunched together.

This completes the description of the plans adopted for the strengthening of the bridge for the additional railway loads. The execution of these plans and the appearance of the finished work is illustrated in the views which accompany the papers by Messrs. Fay and Moses.

Erection of the Street Railway Bridge in 1907 and Corrosion of the Original Bridge Then Disclosed.

By Mr. Fay.

When the southerly half of the bridge was stripped, in October, 1907, preparatory to the erection of the street railway structure, the old metal work was cleaned of scale and rust and its condition was found to be much worse than had been expected from an examination made in the summer of 1906, and showed in a striking way that the usual examination of such a bridge from below, which means climbing a ladder between the passages of trains, looking at a few selected places in the dark and clean-

ing off rust scales on those parts as best as one can under the circumstances, is by no means real inspection and cannot be relied upon to determine the true condition of a bridge in which corrosion is well under way.

The worst effects of corrosion were generally found at the easterly end of the bridge, over and near track No. 1, which is the outward bound express track of the Boston & Albany Railroad. This track is used also by switch engines in making up trains in the railroad yard just east of the bridge. The total train movements beneath the structure are between five hundred and six hundred on each week day, and about eighty on Sunday; and frequently the switch engines will stop underneath the bridge, discharging steam and smoke, which hang for a considerable time just under the bridge floor.

The floor beams at the east end of the bridge were the parts found to be in the most dangerous condition. Although built before the days of modern street cars, and, as before stated, designed only for a uniform load of 80 lb. per square foot, and a single 20-ton wagon, these floor beams were called upon to support two car tracks, each carrying cars up to 26 tons in weight, in addition to the usual and frequent highway traffic at each side of the roadway. If these wrought-iron beams had been as good as new they would have been subjected, under this loading, to unit stresses of about 15 000 lb. to 16 000 lb. per square inch in tension, no allowance being made for impact. As a matter of fact, the beams in the worst condition had corroded to such an extent that their webs, originally $\frac{3}{8}$-in. thick, were reduced to $\frac{3}{16}$ in., the outstanding legs of their flange angles were reduced from an original thickness of $\frac{1}{2}$ in. to about $\frac{1}{8}$ in., and the lattice bars connecting the flanges of the two halves of these doubled webbed beams were either entirely eaten off or were so thin that they could be broken by blows of a light hammer. The condition of one of these beams is shown in the accompanying view. (Fig. 9.) The wooden stringers rested upon the top flanges of the beams and in this case, as well as in a number of others, the outstanding legs of the top flange angles were broken entirely off at the track stringers as a result of the pounding administered by the heavy street cars. The broken flanges are not the worst feature, however, for a part of the vertical leg of the flange angle and, in the longer beams, what was left of one or two vertical bars on the inside of the web, still remained to act as flange section; and the notching of the stringers upon the beam doubtless served to give some lateral support to the top flange to make

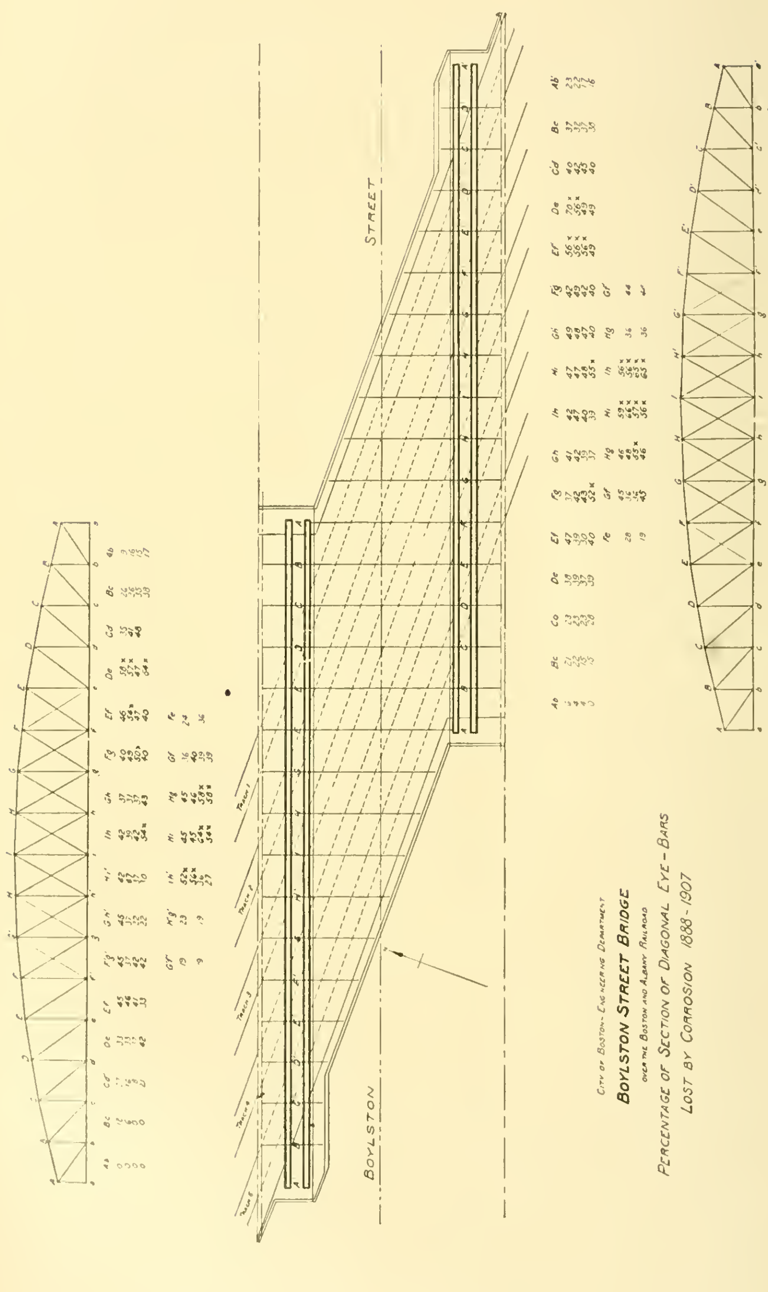

City of Boston - Engineering Department
Boylston Street Bridge
over the Boston and Albany Railroad
Percentage of Section of Diagonal Eye-Bars
Lost by Corrosion 1888-1907
Street
Boylston

Fig. 10.

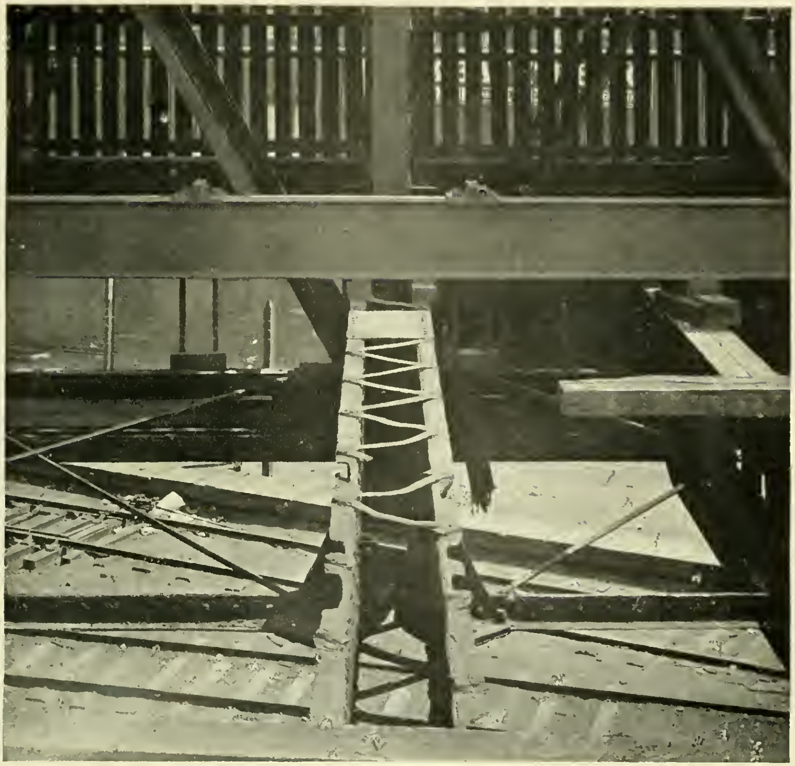


Fig. 9. Floor Beam of Original Bridge, Corroded and Broken.

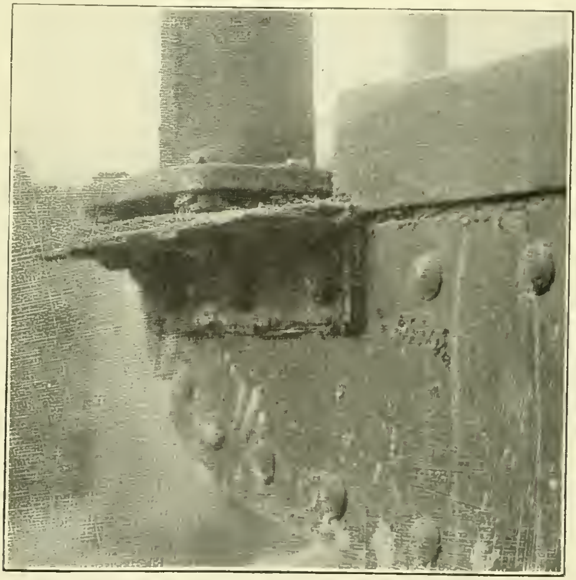


Fig. 12. Relative Corrosion of Cast and Wrought Iron.

FIG. 11. TYPICAL CORRODED DIAGONAL OF ORIGINAL TRUSSES.

up for the loss of the latticing. It will be noted that the floor beam was a double webbed beam and upon every other one of the stringers met in a butt joint, in which case the stringer reaction had to be carried entirely by one half of the beam, dependence being placed upon four plate and angle diaphragms to transmit the proper portion of the load to the other half of the beam. The diaphragms were made of $\frac{5}{16}$-in. plate, and, like the rest of the member, were badly rusted. In the view shown, the diaphragm plate was so far gone that a diaphragm nearest the tracks was cracked entirely through, owing to the heavy car traffic. In such a case, one half of the floor beam had to carry the whole of a stringer reaction except for that part of the load which might be carried to the adjacent stringer by the street car rail.

In the trusses, the easterly portion naturally showed the greater corrosion. The bottom chord bars were some distance below the flooring and were less subject to corrosion from locomotive fumes, although they showed the effect of blast action from the locomotives. These bars in most cases were corroded less than $\frac{1}{8}$ in. on each exposed surface, and as they were originally thicker than the diagonals, the percentage of metal lost in the chord bars was, on the whole, considerably less than that of the diagonal bars. The locomotive fumes would rise to the under side of the floor planking and the stringers would keep the gases pocketed there and would prevent them from being blown away; consequently the worst condition of corrosion of the trusses was found in the web members just beneath the planking. Here, in a large number of cases, from $\frac{1}{8}$ in. to $\frac{3}{16}$ in. of metal had been eaten away from each exposed surface. Post channels, whose webs were originally nearly $\frac{7}{16}$ in. in thickness, had been rusted until the webs were not more than $\frac{1}{8}$ in. thick, and their tie plates and latticing were badly rusted also. Many eye-bars having an original thickness of $\frac{3}{4}$ in. were found with minimum thicknesses of $\frac{7}{16}$ in., $\frac{3}{8}$ in. and even less, and as their edges as well as their sides were corroded, the loss of section in a number of the diagonals was as high as 50 per cent. to 60 per cent., reaching in one case a loss of 70 per cent. Fig. 10 is a diagram showing the extent of corrosion in the several eye-bars of the old trusses. Fig. 11 shows typical corroded diagonals.

An instance where wrought iron corroded vastly more than cast iron under precisely the same exposure appears in the accompanying photograph (Fig. 12) of the base of a railing post supported on the end of a sidewalk bracket. The post base is of

cast iron; the shelf angle on which it rests and the bolts are wrought iron. Both were just beneath the sidewalk floor, where, as just described, the corrosion was worst. If anything, the casting was less favorably situated, being directly under the planking and where the gases hung longest. Little is left of the shelf angle but laminæ of rust; the casting shows a rusty surface but is in excellent condition and was put back for another twenty years in the new bridge.

The condition of the city bridge was such that it was deemed unsafe for further traffic, and extensive reconstruction was at once determined upon as an imperative necessity.

In connection with the destruction of the original Boylston Street Bridge, it should be noted that the amount of headroom beneath such a bridge has an important influence upon corrosion. At this bridge, as is the case of many of our city bridges over railroads, the headroom from top of rail to the clearance line of the bridge was only about 15 ft., and with such low headroom the corrosive action of locomotive fumes has generally been comparatively rapid. On the other hand, at many bridges where the headroom is 18 ft., the effect of the gases under substantially similar conditions of time and railroad traffic has generally been less marked.

The contract for building the street railway bridge had been let to the Boston Bridge Works, which concern had built the original bridge in 1888. The erection of the street railway structure was begun September 30, 1907, in accordance with a scheme of erection proposed by Professor Spofford, travel being maintained upon both sidewalks, upon the northerly car track and the northerly half of the roadway. The old southerly trusses had to support the southerly street railway truss until the latter was fully assembled and swung. Although there was some decrease in the dead weight of the floor, and the live load on the old southerly trusses was limited to an amount considerably less than that which had been previously using the bridge, the contractor was unwilling to assume the risk of placing the dead weight of the new truss upon the old trusses until some of the worst corroded diagonals of the latter had been strengthened.

A reinforcement was used consisting of a U-shaped bar bolted to the diagonals above the point of corrosion, combined with another U-shaped bar around the bottom pin, the latter bar being adjustable and connected to the first by a casting.

After the erection was well under way the contractor asked permission to close the whole roadway to travel in order to work

on both trusses and the entire floor system at one time, claiming to be able to materially hasten the completion of the work if this were done. This permission was granted by the city and by the Boston Elevated Railway Company, and the entire bridge, except the two sidewalks, was closed to travel October 25, 1907. The erection of the street railway bridge was carried on to a point where the trusses, all of the new floor beams and the new bracing were completed. The Boston Elevated Railway Company desired to resume street car traffic across the bridge at the earliest possible moment and to put into service cars weighing 42 tons, and as it would have taken some time to get an appropriation from the city for rebuilding the original structure, and still further time before the work of rebuilding could have been begun in the field, the scheme of putting on a permanent floor was abandoned and the Boston Elevated Railway Company proceeded to lay temporary tracks. As the old city floor beams were insufficient to carry these tracks near the abutments, a temporary construction of I-beams was put in at each end of the bridge. This construction consisted of a pair of 20-in., 65 lb. I-beams placed longitudinally upon the old floor beams near the trusses; and to these longitudinal beams were hung I-beams which served as temporary floor beams for the support of the track stringers, the opposite ends of these temporary floor beams being supported upon blocking at the abutment.

The temporary track construction consisted of track stringers and supplementary stringers of wood upon which was laid a 3-in. plank floor about 20 ft. wide for the length of the bridge, a substantial fence being provided at each side of this flooring. On top of this planking T-rails were laid at an elevation considerably above that of the rails in the former bridge, the rails being above the tops of the parapet stones. No attempt was made to provide for team travel by laying flooring up to the top of the rails.

The street railway structure was completed and the temporary track was opened to travel on November 20, 1907, and during the whole work travel had been maintained upon both sidewalks. From November 20, 1907, until the work of rebuilding the city structure was begun in July, 1908, foot travel was continued on both sidewalks and all of the car travel of Boylston Street crossed the bridge on the temporary tracks, but no team travel was allowed and the Elevated Railway Company maintained a flagman at all times to prevent teams from attempting to cross the temporary floor.

In anticipation of the closing of the bridge to all travel during the work of reconstruction by the city, the Boston Elevated Railway Company secured a location, and in June, 1908, laid temporary tracks from Boylston Street to Massachusetts Avenue through Hereford and Newbury streets. All car travel was diverted to this temporary route soon after July 1, 1908, just before the rebuilding of the old city bridge was begun.

Care of the Original Bridge.

By Mr. Fay.

Before leaving the subject of the original Boylston Street Bridge to take up that of its reconstruction, it may be well to pause for a moment in our description to answer some questions that may arise as to the care and condition of the old bridge during its nineteen years' life. Was the bridge kept properly painted? Why did corrosion take place to such an alarming extent? Why was not its true condition known before the building of the street railway bridge was begun? To answer these and similar questions, a general statement regarding the maintenance of bridges by this city may be illuminating.

The responsibility for the maintenance of the city bridges in Boston lay for many years, and rests at present, with the superintendent of streets, his duties being delegated to a deputy superintendent of bridges, who is the officer in charge of the bridge division of the street department. Prior to 1891, and during the years 1906 and 1907, the bridge division was classed as a separate department whose superintendent was appointed by the mayor. All expenditures for maintenance are met from appropriations for the bridge division. The city engineer is required by ordinance to report annually upon the condition of the bridges and to supervise all repairs affecting the safety of the structures. Annual inspection of all bridges is made by the engineering department so far as conditions will allow, more frequent inspection being made whenever the city engineer deems such inspection necessary. The city engineer, however, has not had power to enforce his recommendations and generally they have been ignored.

This arrangement has not worked well in practice, and for years our city bridges have been suffering for want of proper care. Maintenance meant the renewal of the floor surfacing and the painting of such metal work as is easily accessible and seen by the public. The more important and less accessible metal work, that below the bridge floor, has been constantly neglected,

dirt has been allowed to accumulate wherever it could find a lodging place, and only at infrequent intervals has any pretense been made of cleaning this metal work of dirt, scale and rust, and repainting it. Indeed, it is not stating the case too strongly to say that the maintenance of the bridges as a whole has been grossly inadequate, proper inspection has not been possible under existing conditions, and many bridges, particularly those over railroads, have deteriorated to such an extent that to-day they may be almost unsafe for public travel.

Boylston Street Bridge reached the danger line in nineteen years' service; Massachusetts Avenue Bridge over the Boston & Albany Railroad has just been rebuilt; Huntington Avenue Bridge over the same railroad has reached such a bad condition that an appropriation for rebuilding it has already been made; while other bridges over railroads will have to be repaired or renewed in the near future or else closed as unsafe for public travel.

Boylston Street Bridge may be cited as a typical case because in this structure the consequences of neglect have been made manifest. The speaker does not mean to imply that neglect was primarily responsible for the destruction of this bridge. Unquestionably, the chief cause was to be found in the constant presence of locomotive fumes which formed a powerful mordant and steadily attacked the metal, and the next important factor was the presence of heavy street cars, which pounded the floor beams to pieces after the gases had done most of their deadly work. Nevertheless, it is probable that if the city engineer's recommendations had been followed and the metal work had been kept properly cleaned and painted, the life of the trusses at least, if not the whole bridge, would have been prolonged for a number of years.

As for the inspection of such a bridge in which corrosion is well under way, it is found to be practically impossible to make a thorough, reliable examination of the structure from below. With trains passing at frequent intervals, even on Sunday, with the difficulty of cleaning off scale and rust under the existing conditions, and with the generally poor condition as to light, such inspection must, at best, be very superficial and places of most vital importance are often wholly inaccessible. Public safety as well as economy demands that in the case of bridges over railroads in which there is unprotected metal work beneath the floor, the entire flooring should be removed at frequent intervals and all such metal work thoroughly cleaned, examined and painted.

Rebuilding of the City Bridge.

By Mr. Fay.

After a delay of nearly six months, the city government of Boston appropriated, on April 2, 1908, the sum of $60 000 for the rebuilding of the city's bridge. Meantime, plans for the work had been prepared by the engineering department, and bids had been called for, to be received on April 3. On that date the contract for rebuilding was let to the Boston Bridge Works, Incorporated, the lowest bidder, for the sum of $52 800. The work of rebuilding provided for raising all trusses so that they should be well above the floor and should thereby be protected in the future from further destruction by locomotive fumes. The top chords of the old trusses, which were in good condition, were to be retained, but the posts, diagonals and bottom chords were to be entirely renewed. The floor beams of the street railway bridge were to be hung to their longitudinal girders by riveted hangers, while the new floor beams for the city structure were to be hung by eye-bar hangers. (See Fig. 8.) The metal work for the city structure below the floor was to be protected, so far as possible, by concrete, although it was found impracticable to so protect the eye-bar hangers and the bottom lateral bracing. Provision has been made for the easy renewal of these latter members when necessary. The new city floor beams are plate girders 3 ft. 11 in. deep back to back of angles, their ends being cantilevered to form brackets for the support of the sidewalks. Upon the top and bottom flanges of these beams are placed channels solely for the protection of the metal work of the beam, no dependence whatever being placed upon these channels as carrying stress. (See Fig. 13.) These channels are 12 in. wide and have a web ½ in. thick. On the bottom flange the channels are riveted by countersunk rivets. As the bottom channels have to resist only the blast of the locomotives, it is thought that they will last for a great many years, perhaps for the whole life of the present structure. The top channels, on the other hand, are in a position where they will be subjected to locomotive fumes as well as to moisture which will work through the wooden flooring; these top flanges carry the wooden stringers of the bridge, which fact will hasten their destruction. Consequently, the top channels are not riveted to the floor beams, but are attached to the top flanges by brass bolts in such manner that they may readily be replaced by new channels when necessary.

The photographs shown in Figs. 14 to 16 illustrate the con-

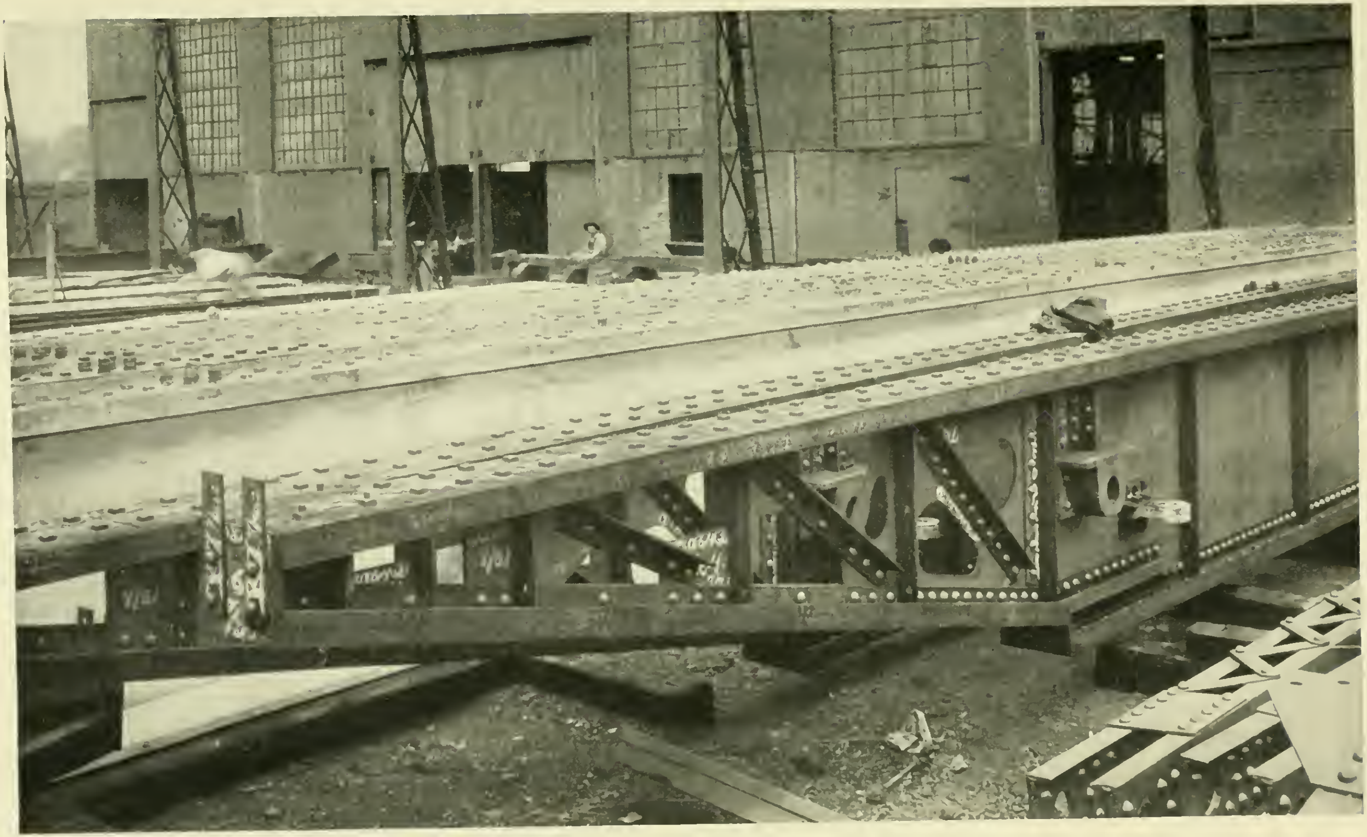


Fig. 14. Bracket End of Typical Floor Beam of New City Bridge, before Concreting.

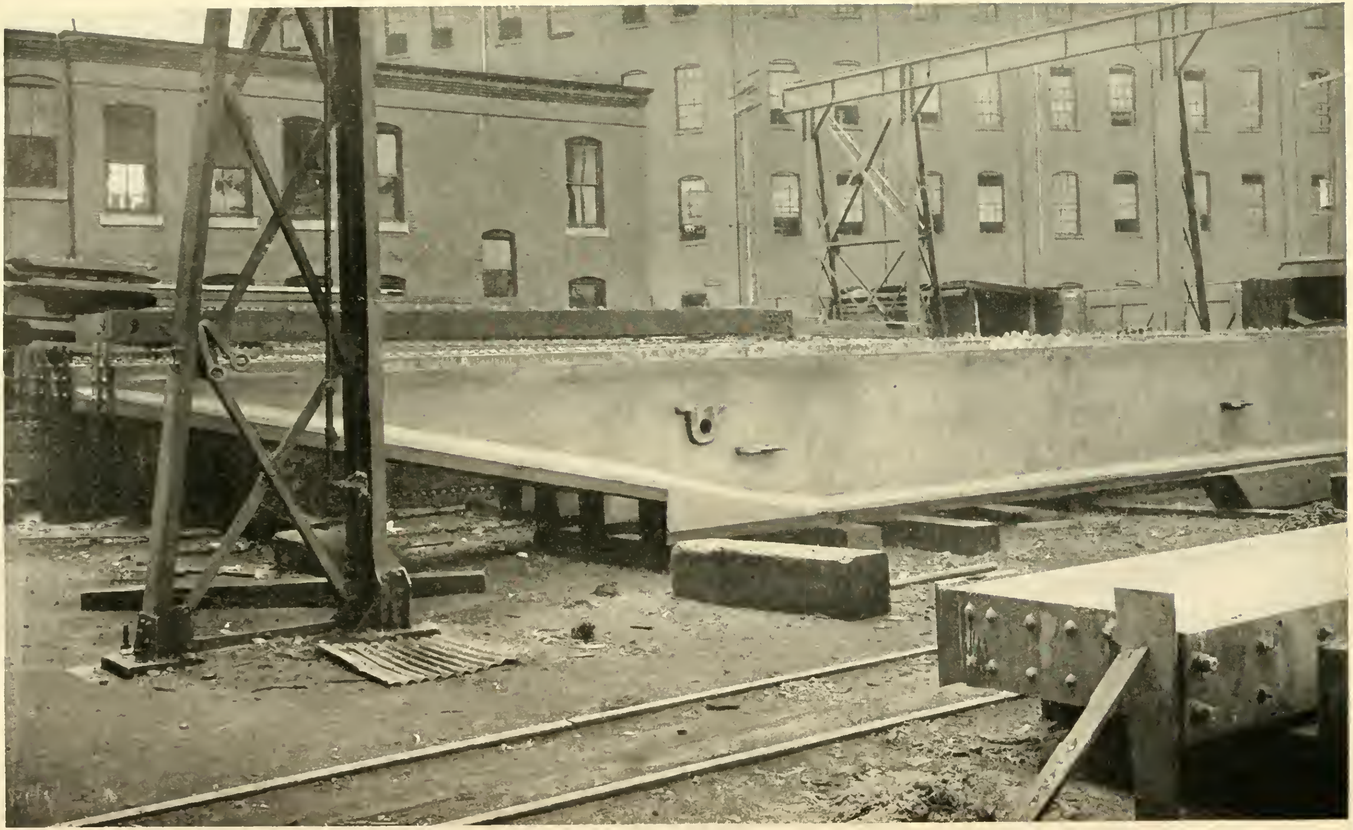
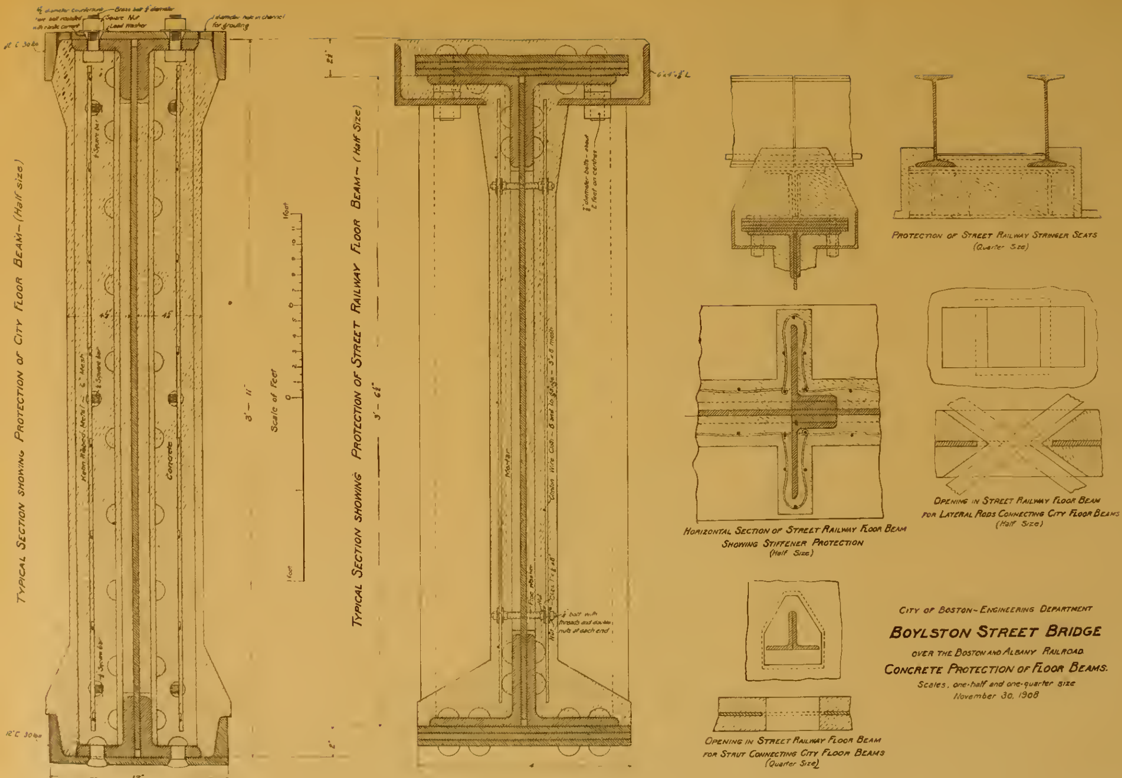


Fig. 16. New City Floor Beam with Concrete Protection Completed.



Typical Section showing Protection of City Floor Beam ~ (Half size)
Typical Section showing Protection of Street Railway Floor Beam ~ (Half Size)
Scale of Feet
Protection of Street Railway Stringer Seats
(Quarter Size)
Horizontal Section of Street Railway Floor Beam
Showing Stiffener Protection
(Half Size)
Opening in Street Railway Floor Beam
for Lateral Rods Connecting City Floor Beams
(Half Size)
Opening in Street Railway Floor Beam
for Strut Connecting City Floor Beams
(Quarter Size)
City of Boston ~ Engineering Department
Boylston Street Bridge
over the Boston and Albany Railroad
Concrete Protection of Floor Beams.
Scales, one-half and one-quarter size
November 30, 1908

Fig. 13.

crete protection of the floor beams, while the same was being put in place at the yard of the Boston Bridge Works. The top channels were bolted in place and holes were made through the stiffener angles for the rods which support the reinforcing metal.

Fig. 14 shows the bracket end of one of these beams with its open web.

Fig. 15 shows the process of concreting the beams as well as the method of placing the reinforcing metal. One-half-inch steel bars are run through the holes in the stiffener angles at the top, bottom and middle of the beam on each side of the web. To these ½-in. bars are wired sheets of Kahn ribbed metal of 6-in. mesh. Concrete consisting of one part Portland cement, two parts sand and four parts fine broken stones is being placed on one side of the beam while the latter is lying on its side. Although not called for in the specifications, the surface of the concrete was finished practically as a granolithic surface and an excellent job of concreting was obtained. In this view will be noticed castings projecting from the concrete at about mid-height of the web of the floor beams. These castings are to receive the bottom lateral bracing, which is to be attached to them by means of pins in order that the bracing may be readily renewed when corroded. It was desirable to have the castings made of some metal which would be non-corrosive, as the castings themselves could not be renewed without breaking into the concrete and exposing the web of the floor beam. Several types of composition castings were considered and finally it was decided to use a casting consisting, approximately, of 70 per cent. aluminum, 3 per cent. copper and 27 per cent. zinc. This composition has a tensile strength equal to that of ordinary bronze and is probably less liable to corrosion on account of its small percentage of copper. This metal is known as Macadamite and is made by the United States Macadamite Metal Company, of Brooklyn, N. Y.

Fig. 16 shows one end of a floor beam in which the concreting has been completed. Here will be seen two of the aluminum castings for the connection of the bottom lateral bracing as well as the iron casting which is to receive the pin of the eye-bar hangers. As this latter casting is of relatively thick metal and projects only slightly beyond the concrete, it was thought unnecessary to make this casting of composition metal.

Fig. 13 shows further details and a comparison of the methods used for the protection of the city and street railway floor beams with concrete.

On the city floor beams the concrete protection was made

$4\frac{1}{4}$ in. thick on each side of the web. The steel reinforcement, consisting of Kahn rib metal of 6-in. mesh, was placed about $1\frac{1}{2}$ in. in from the face of the concrete and was wired to the $\frac{1}{2}$ in. square bars running longitudinally through the top, bottom and middle of the stiffener angles. The stiffeners were spaced at regular intervals to accommodate standard widths of reinforcing metal. At the tapered ends of the beams, acting as sidewalk brackets, the rods were continued, but the Kahn metal omitted and a lattice web used, which allowed good bond between the concrete slabs on the two faces of the bracket. The bottom flange channel, used mainly to resist blast action of the locomotives, was riveted to the flange angles with countersunk rivets in the hope that the countersunk heads, being less exposed to the blast, would last longer than button heads. The countersunk rivets were not chipped. At the top flange the protecting channel was bolted to the flange angles with brass bolts before the concreting was done. To guard against possible electrolytic action between the brass and steel, $\frac{3}{4}$ in. diameter bolts were used in $\frac{15}{16}$-in. diameter holes, the holes in the channel were countersunk on the top side, the spaces surrounding the bolts were filled with elastic cement, and lead washers were used between the brass nuts and the top surface of the channel. The beams were concreted while lying on the side, as shown in Fig. 15. After the beams had been concreted they were allowed to stand for some time in the bridge shop yard in an upright position, as shown in Fig. 16, and while the moisture was drying out of the concrete the latter would shrink away from the top flange to a slight extent. This action had been foreseen and provision made for grouting the top flanges, after the concrete had set. Holes 1 in. in diameter had been drilled every 4 ft. near the outer edges of the channels and grout was poured in through a long-nosed tunnel under a head of some six or eight inches. Grout consisting of two parts Portland cement and one part sand was first tried, but without success, as it would not flow properly. Neat Portland cement grout was next tried and found to flow freely for a distance of 6 or 8 ft. each side of the grouting hole. The top channel was removed from some of the beams while the latter were at the yards of the Boston Bridge Works, and in all cases where neat Portland cement grout had been used the grouting was successful, the voids in the concrete having been well filled.

During the rebuilding of the city's bridge the Boston Elevated Railway Company decided to place a concrete protection upon the floor beams of the street railway structure, and, at the

request of that company, the design of the protection was made by the engineering department of the city, the details being shown in Fig. 13. In order not to add too much dead weight to these beams it was decided to make the concrete only 2 in. thick on each side of the web and to encase each stiffener angle. The whole of the top flange and the top side of the bottom flange were protected. No protection was provided for the under side of the bottom flange, partly on account of limited headroom, but more especially because it was thought that the protection could not be held in place, owing to the blast from locomotive stacks, the tops of which come within a few inches of the beams, and also because of the likelihood of the concrete or mortar cracking at the edges of the flange and exposing the reinforcing metal to corrosion. Slabs or pieces of mortar falling upon passing trains would be a source of danger to passengers within the cars, as has been shown by experiences elsewhere. To hold the concrete protection in place at the top flanges, rivets were cut out from the outer gage lines at intervals of about 2 ft. and angles were bolted to the underside of the flange, a clearance of 1 in. being provided between the angles and the edges of the flange plates, and an equal or greater clearance being allowed at the under side of the flange. The concrete at each side of the web was held by Clinton wire cloth, 3 in. by 8 in. mesh, 8 and 10 gage wires, held by $\frac{1}{4}$-in. bolts through the web, holes for the bolts being drilled in the field and the bolts being provided with threads, double nuts, clips and pipe washers at each end to hold the wire cloth in proper position. A wire cloth reinforcement was placed around each stiffener angle and wired to the reinforcement on the web. Wooden forms were provided on each side of the beams, reaching from the bottom to the reinforcement angles at the top flange. Openings through which concrete was placed were left just under the top flange.

The concrete protection of the street railway floor beams was really a mortar protection, mortar consisting of one part Portland cement and two parts sand being used for the web protection and a grout made of 1 to 1 Portland cement and sand being poured in and around the top flange after the web protection had been put in place. All of the work in connection with the protection of the street railway floor beams was necessarily done in the field, as it was not feasible to remove these beams from the bridge. As their protection is of lighter construction than that of the city's beams, and was placed under considerable difficulty, owing to the constant passing of trains beneath the

bridge, it may be less durable than that of the city floor beams. The results obtained upon the street railway beams were very satisfactory, however; to all appearances the concrete is sound and continuous, without cracks or serious voids, the contact with the steel is good, and it is hoped that the protection will perform satisfactory service for many years. The only steel now exposed to corrosion anywhere beneath the floor is the lateral bracing and the channel stringers in the city's bridge and the track stringers on the railway bridge and the floor beam hangers of both bridges, none of which can be conveniently protected, and all of which, except, perhaps, the hangers of the railway floor beams, are easily removed and renewed.

Erection of the Three Boylston Street Bridges from the Contractor's Standpoint.

By Mr. Moses.

The three steel bridges described in the previous papers were all built and erected by the Boston Bridge Works, of Boston,

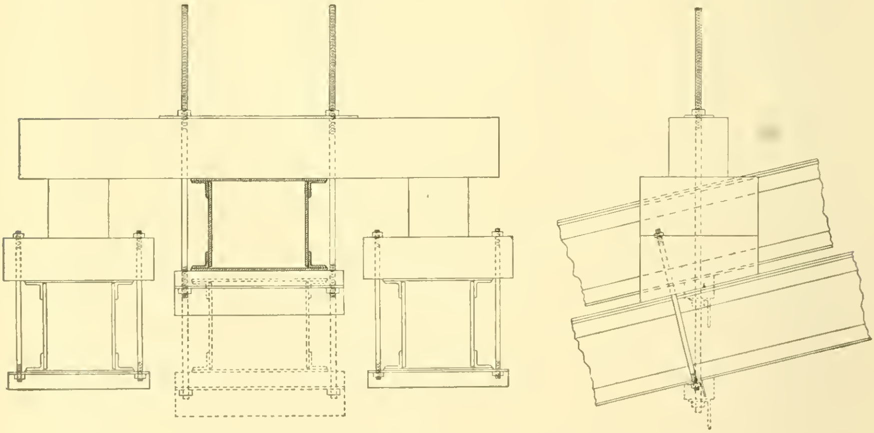


Fig. 17. Method of Temporarily Supporting Top Chords of Railway Trusses in Raised Position.

Mass. An account of the erection of the first bridge appears in Mr. Fay's second paper. The erection, in 1907, of the additional trusses and floor to carry the Boston Elevated Railway Company's tracks involved no special difficulties beyond the need of extreme care in avoiding any interference with the railway traffic below the bridge. The lower chords with the lower half of the posts and diagonals were erected in place. The top chords with the upper half of the posts and diagonals were erected about 2 ft. above their final place in order to give room for entering the pins

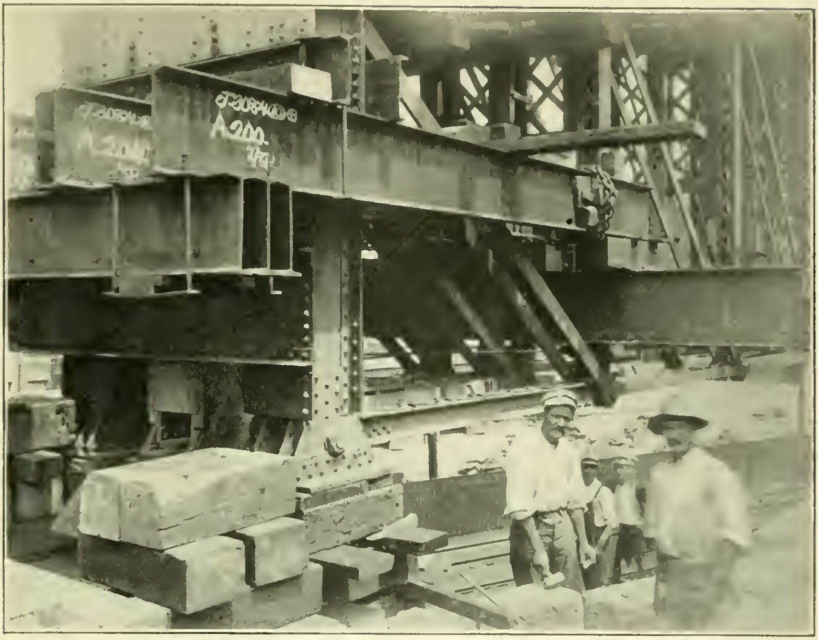


FIG. 18. TEMPORARY FRAMEWORK FOR RAISING ENDS OF TRUSSES.

FIG. 19. TEMPORARY TIMBER BENT FOR RAISING ABUTMENT ENDS OF SKEW FLOOR BEAMS.

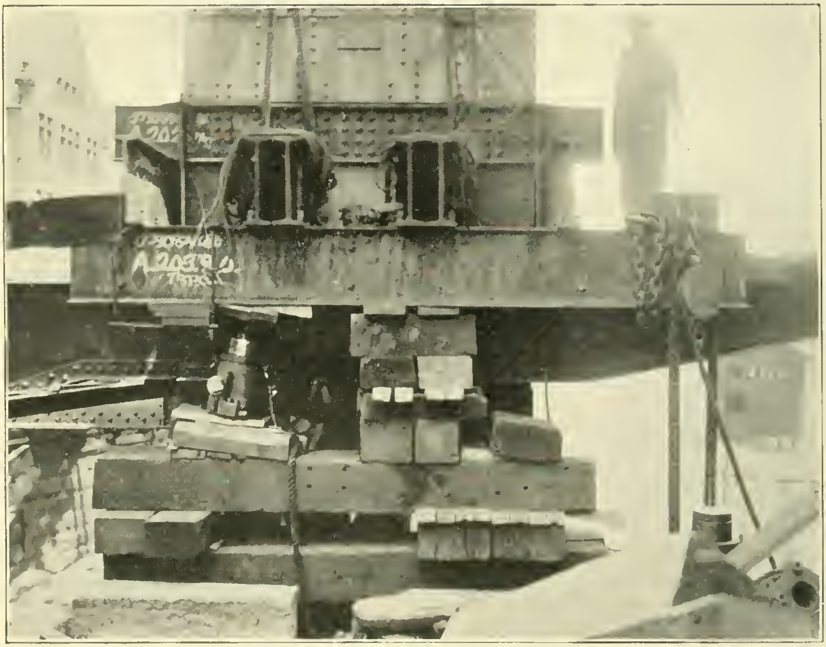


Fig. 20. Jacking Trusses into Position Laterally after Raising Bridge.

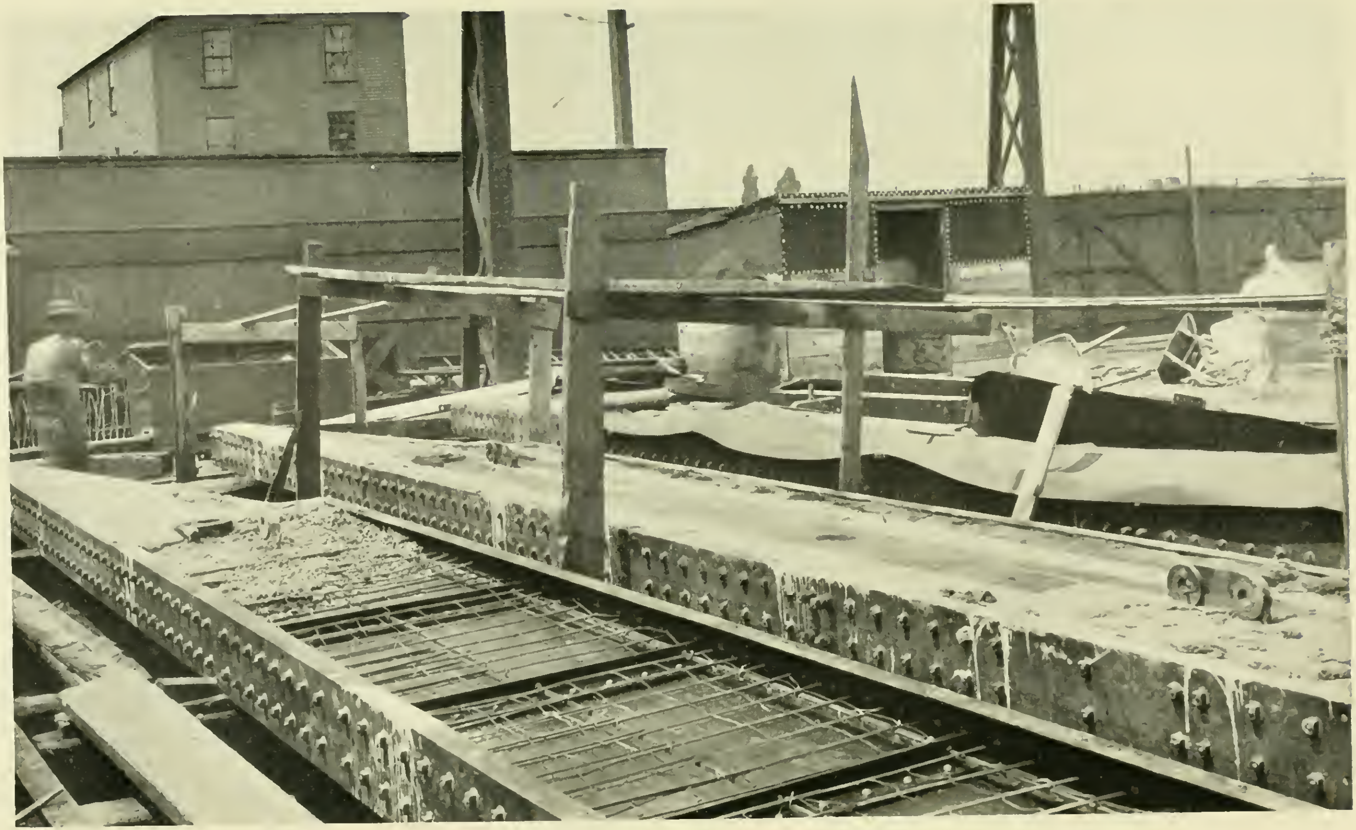


Fig. 15. Placing Concrete Protection on Webs of New City Floor Beams.

Fig. 24. Erection of New City Floor Beams.

FIG. 25. ERECTION OF NEW CITY FLOOR BEAMS.

FIG. 26. STIFF-LEG MOVABLE DERRICKS AT WORK ERECTING NEW CITY FLOOR BEAMS.

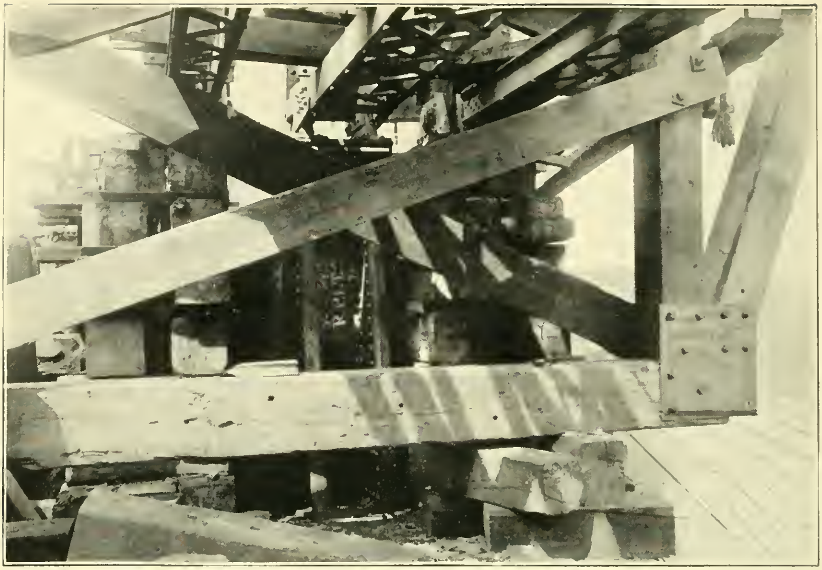


Fig 21. Permanent Steel Pedestal Support for Center Truss.

Fig. 22. Temporary Bracing of Trusses during Raising of Bridge.

and driving the chord splices. They were supported temporarily by blocking and hanger rods arranged as shown in Fig. 17. When the pins were all in, and riveting completed, the nuts on the hanger rods were turned by men working simultaneously at all points, thus lowering the upper half of the truss. The diagonal bars were coupled and screwed up as the truss was lowered, and the post joints riveted when the truss was in its final position. The top bracing between the two outside chords was then replaced and the new spacing struts were riveted together. The new trusses were cambered to match the old trusses, whose outline was somewhat irregular. Temporary tracks were then laid to carry the street cars and fences built to keep the rest of the roadways safely closed. The sidewalks were kept open to traffic throughout the work.

The erection, in 1908, of the new city trusses was, on the other hand, a difficult and dangerous undertaking. The working room available was very limited. A city fire station at one end of the bridge prevented occupancy of the street to a large degree. At the other end of the bridge the sidewalks had to be kept open to give entrance to the stores facing the street, and the street itself could only be occupied for a short distance. No staging of any kind was possible below the bridge, the clearance between metal and trains being but a few inches, and all five tracks being in constant use, train movements averaging over one a minute at some hours of the day. Guy ropes for derricks were out of the question. Moreover, it was necessary to give opportunity to the city to change the parapets and repave the street adjoining the bridge. The telephone and electric light companies were also obliged to take up their old conduits and wires that had been carried by the old bridge and relay them, building new manholes and underground conduits to receive them. Similar work was done by the street railway company, besides laying their new tracks when the structure was ready to receive them. All this work had to be done during the erection period.

The necessity of doing the work in the shortest time possible was very great and the contractor was placed under a heavy penalty for every day taken in excess of the sixty days allowed by the contract. A corresponding premium was allowed for completion before the specified time. The work was deemed to be of too dangerous a character to be safely conducted at night. Great care had to be constantly exercised to avoid the possibility of falling tools, hanging ropes or projecting timbers that would be dangerous to trains, flagmen being kept constantly on

watch below. The smoke and steam from the trains and switch engines would also have made work by artificial light much more dangerous. Erection was, therefore, carried on by daylight only, two shifts of men, working from 4 A.M. to 8 P.M., being employed. As many men were put on the work as could be used, but the number was limited as one operation had to succeed another to an unusual degree. All steel work was completed at the shop before erection was begun, and the lumber for the floor was framed ready for placing before being brought to the site. A compressed air plant was installed to furnish power for drilling and riveting. The 100-ton hydraulic jacks used were tested at the shop in a machine built for the purpose, and two specially designed, movable, stiff-leg derricks were constructed. The erection foreman was furnished with unusually complete drawings and shipping lists, and the draftsman who had checked the drawings was kept on the job.

The first operation required after removing the temporary tracks from the bridge was raising the entire structure about 7 ft. vertically. This was done by constructing a framework of heavy beams at each end post (Fig. 18) that formed cantilevers projecting beyond the trusses. Two 100-ton jacks were placed, resting on the abutments and bearing up under each set of beams. All four corners were jacked up simultaneously, the blocking under the truss pedestals being carried up under them with great care and kept constantly tight with wedges. The load lifted was over 700 tons and about the limit of the jacks' capacity, and the possibility of failure of a jack at any moment had to be provided against.

The sharp skew of the bridge caused one end of most of the floor beams to bear on the abutments. A timber bent was built on each abutment, straddling the floor beams. Rods attached to the beams passed through the caps of these bents. These rods were threaded and the beams raised by turning nuts on top of the caps. (Fig. 19.)

After raising the bridge it was necessary to shift the trusses laterally as much as 10 in. in some cases. This was accomplished by setting a jack on a slope, as shown in Fig. 20.

When the trusses were in correct position, steel pedestals were placed under the center trusses. (Fig. 21.) These pedestals furnished permanent supports for the center trusses, the outside trusses being supported by new concrete and granite extensions to the abutments that also inclosed the steel pedestals. Before this masonry could be built, the blocking under the outside

trusses had to be removed, and before this could be done the weight of the two outside trusses had to be transferred to the center truss. When this was done, and the blocking removed, the structure would evidently be in a very top-heavy condition. Every precaution possible to prevent the trusses overturning or buckling at this time was deemed necessary, the contemplation of such an accident with its likelihood of causing a serious train wreck as well as the destruction of the bridge itself amply justifying the consideration of all conceivable methods of handling the erection at this stage. The plan adopted represents the result of much study of many schemes.

Timber portals were constructed at each corner of the bridge. These portals were bolted to the top chords and were supported on the front edge of the abutments in front of the new masonry. (Fig. 21.) Additional struts and guys were provided (Fig. 22) where possible, but the curvature of the top chords, combined with the sharp skew of the bridge, made any bracing from truss to truss impracticable. The abutments were built as quickly as possible and the truss shoes wedged up on them so as to give stability, but not sufficiently to bring the truss weight on the new masonry before it had set.

While the new masonry pedestals were being built under the outside trusses, the old floor beams were removed, and floor beams for the street railway track that were erected in 1907 were lowered to their former level. This work was done by the stiff-leg derricks advancing on to the bridge from either end. The old beams had to be cut in pieces to free them from the trusses. The street railway beams were supported from the center trusses by new hangers. As fast as they were lowered, the steel stringers for the tracks were put in place and they, in turn, furnished supports for the advancing derricks.

The bridge having been raised and the old floor removed, or lowered, all portions of the outside trusses, except the top chords, were removed and replaced with new material. The weight of these trusses was first transferred to the center trusses by blocking and hanger rods, as shown by Fig. 23. A short block was placed on the center truss. On top of this a transverse timber was placed with hanger rods that supported blocks under the outside chords. This blocking was placed at each panel point (Fig. 22) and by screwing up on all the rods simultaneously the weight of the outside trusses was transferred to the center trusses, and at the same time the outside trusses were relieved of all strain. It was then possible to pull out the pins and remove

the old posts and diagonal bars. About 150 tons of old material were removed in this way and replaced with about 300 tons of new material. When the outside trusses had thus been renewed, they were lowered to their bearings on the new concrete and granite pedestals. The blocking was then rearranged, about as shown in Fig. 17, and the center truss was raised and adjusted to correspond with the camber of the new outside trusses. It will be recalled that the center truss had all its diagonals adjustable and was originally erected to match the somewhat distorted outline of the old trusses.

The next operation was the erection of the new floor beams. The longest beams were 80 ft. long, and weighed, with their concrete covering, about 22 tons each. They had been concreted at

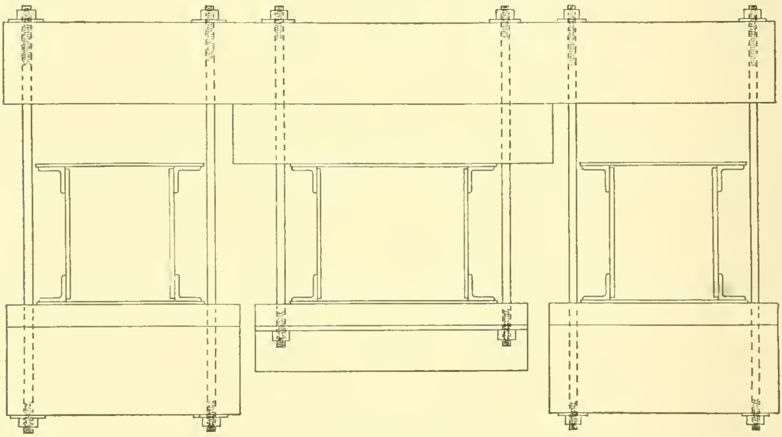


Fig. 23. Method of Temporarily Supporting Top Chords of Original Trusses upon Top Chord of Railway Truss.

the shop some time in advance and were loaded on a special train of cars and brought to the bridge on one of the tracks underneath at an early hour on a Sunday. From these cars they were hoisted at available times between the regular train movements on the other tracks. Both derricks were attached to each beam in turn, the beams raised from the cars, swung about and hoisted into place. (Figs. 24 to 26.)

The floor beams that carry the street railway tracks were concreted next, some 35 yd. of concrete being placed for this purpose. The lumber for the floor, amounting to about 100 000 ft., was then laid; two coats of paint given the entire structure; and the old curbs and scuppers replaced. About 500 ft. of old fence was repaired and replaced on the bridge and new pipe railings attached to the trusses. There were in all 5 500 old

rivets cut out, 2 500 new holes drilled and 6 500 new rivets driven during the erection of the bridge. The changes in the abutments required 125 yd. of concrete and granite. Some 40 tons of steel were manufactured for erection purposes. The entire work was safely completed ten days ahead of the contract time.

DISCUSSION.

MR. HENRY MANLEY. — When the bridge was built the headroom allowed for the railroad was only 15 ft. Since then the bridge has settled a foot or thereabout, and the railroad tracks have settled correspondingly. In the reconstruction a portion of the lost headroom has been regained without raising the approaches to the bridge. This is an important matter as the bridge cannot be raised without great expense and inconvenience, as the whole surrounding area, buildings and all, has gone down together. It is not desirable to still further depress the rails as they were uncomfortably near high-water mark to begin with.

I think an explanation of how the additional headroom was botained would be interesting.

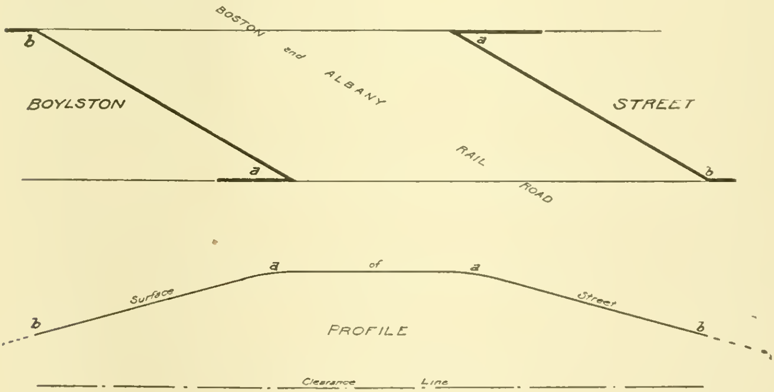


FIG. 28.

MR. S. H. THORNDIKE. — Mr. Manley has spoken of the settlement of the whole region in the neighborhood of the bridge; the records show that it is considerable. The engineer who gave lines and grades for the masonry, which was erected in 1888, remembers it as a particularly accurate job, one of the cases where the contractor and the engineer worked together and the entire structure was set exactly at grade. So there is good datum to start from. In dealing with the masonry during the

past two years, it was found to be 8½ in. below grade at the acute angle and 16 in. at the obtuse angle. I will draw a diagram on the blackboard.

Note that the acute angles (of the masonry) at *a* and *a* are carrying heavier reactions from the bridge and lighter loads from the filling than the obtuse angles at *b* and *b*. Since the obtuse angles went down most, the weight of the filling itself must be the dominant factor which is causing this settlement. The conditions below ground must be singularly uniform since the settlement at the two points *a* is the same within half an inch; these two points are equally loaded, but are quite disconnected and separated by the entire width of the railroad. Again, the settlement at the two points *b* is the same, though they are still more widely separated and have settled under their heavier load nearly twice as much as the points *a*. In 1888 the street was laid out level for the entire length of the bridge, from *b* to *b*. In 1908 the unequal settlement was utilized by laying out the street on a gradient at each end, from *b* to near *a*, the central part only of the bridge being level. The floor beams between *a* and *b* at each end being shorter, were made shallower than those at the middle; the clearance line was kept at substantially the same grade throughout the bridge; and so to-day there is full 6 in. more clearance over the railroad than at any previous time in the history of the bridge.

Mr. Desmond FitzGerald. — Is that action going on now?

Mr. Thorndike. — The levels taken nearby show it is going on to-day.

Mr. William Parker. — Is that settlement any more than Mr. Freeman has told us that the whole of Boston is settling?

Mr. Thorndike. — Mr. Freeman's settlement takes one hundred years to go a foot. This settlement was 1½ ft. in twenty years.

Mr. FitzGerald. — There is one question I should like to ask. How was that concrete protection which was put on top of the street railway floor beam held in place?

Mr. Fay. — The concrete protection had nothing to hold it except the angles bolted to the under side of the flange. The vertical legs of these angles extended as high as the top of that concrete — really mortar, not concrete — so that the mortar is actually held in a trough.

Mr. FitzGerald. — That mortar covering is 2 in. thick?

Mr. Fay. — About 2 in. thick.

Mr. FitzGerald. — It is a question whether a water-works

man ought to say a single thing in regard to such a question as this before us. But naturally my mind is interested in everything connected with the old Boston & Albany Railroad, especially as I built a great many abutments and some bridges over it myself. It seems to me the community was very fortunate in having the reconstruction of this bridge in such good hands — men who thought carefully of every little detail. It seems to me that the problem was very intelligently handled, although I am comparatively rusty and a poor judge with regard to those things now. The way in which the concrete protection was placed in connection with the floor beams seems to me excellent, and all the little details connected with it, especially where metals of different kinds were brought together, were extremely well thought out. It seems to me it shows very strongly the great advantage of putting all such things in good, scientific hands from the very beginning. You can imagine what would have happened if the reconstruction of a bridge of this kind had been put into the hands of ordinary politicians appointed by the mayor. The thing would have been rebuilt as it was built before and probably would have another short term of life.

PRES. J. R. WORCESTER. — It is interesting to notice the fact that the speakers several times referred to this as a case of concrete reinforcing steel. We are more used to its being twisted the other way now-a-days. I think in this case it is a proper use of the term, for while the concrete may not exactly increase the strength, it was certainly put there to increase the life. There is another point to which I wish to call attention, and that is, there didn't seem to be any great amount of difference, as far as I could judge from the description, in the way that iron and steel lasted in this instance, and I should like to ask Mr. Fay whether any particular difference was noticed.

MR. FAY. — It is hard to say what difference, if any, there was, because the conditions under which the two existed were different. The iron was in the floor beams, while the diagonals of the trusses were of steel. The floor beams, I think, had gone very rapidly during the last year or two of their life; that is, it is my belief that, after having reached a certain point of corrosion, the destruction was hastened by the pounding and hammering of the street cars, so that the fact of the flanges being broken off, and, as in one instance, of the diaphragm connecting the two webs of a beam being broken, was due in large part, in my opinion, to the pounding effect of the car traffic. On the other hand, the steel diagonals of the trusses had no such impact or

pounding to contend with and their destruction is simply a case of straight corrosion. Generally speaking, wrought iron will stand up very much better than steel, as shown in the case of the bridge on West Newton Street, over the Boston & Providence Railroad, where the traffic is nearly as heavy, though not quite, as it is on the Boston & Albany Railroad. That bridge was built in 1872 and it is good for some few years yet. It has a clearance of 18 ft. as against 15 ft. at Boylston Street. Generally speaking, it is our experience that wrought iron will last considerably longer than steel; just how much it is hard to say.

Mr. FitzGerald. — Was any part of this work carried on at night?

Mr. Fay. — Not after 8 o'clock. The work was carried on from 4 in the morning till 8 at night during July and August. I may say that the contractor was working under a penalty. He was allowed sixty days, but the work was so excellently handled that it was done in fifty days instead of sixty, so that a bonus of ten days was earned.

Mr. FitzGerald. — Anything drop on the track?

Mr. Fay. — Nothing of any size, except one piece of timber 4 in. by 4 in. in size and about 3 ft. long, used in connection with the forms for concreting the street railway floor beams. Two flagmen were on watch constantly to see that no harm came. Of course, wedges and tools and small articles of that sort fell, as well as a considerable number of rivets, but nothing of large size like a heavy timber was dropped on the tracks. There was one accident to a workman, who fell from the staging on the top of one of the trusses, struck on the staging at the level of the bottom chord of the truss, and fell from there down on to the track. Fortunately, he was not very seriously injured.

The President. — Professor Spofford spoke about Bessemer steel as being (I forget his exact words) a risky sort of metal. It seems to me that steel that will show the results attained by those eye-bars on full-sized tests is something we need not be very much afraid of. I wish we could do it every time.

Mr. L. S. Cowles. — Concerning the question of Bessemer compared with the open-hearth steel, it strikes me that where the steel is subject to impact, the Bessemer steel is less favored. We had a case of building work where in an I-beam a couple of shelf angles were broken off when they would not have been had it been open-hearth steel. Of course, in the rolling, the metal is undoubtedly more or less injured. Where impact is to be considered I should say the open-hearth is preferable.

Mr. FitzGerald. — Mr. Schwab has stated that in ten years from now steel will all be manufactured by the electrical process.

A Member. — I think all of us had a good chance to see that in the wire nails used for shingling. Use wire nails and in five years your shingles will be flying all over the neighborhood.

A Member. — Isn't the question of Bessemer versus open-hearth steel really a question of phosphorus? I have known beams to break in two as the result of being dropped from a wagon to the ground.

The President. — I think the member who has just spoken is right that phosphorus is generally the element in Bessemer steel that is dangerous. But I think that really the distinction between the two processes is rather that by the open-hearth process it is possible to control the exact chemical composition of the steel, whereas, by the Bessemer process, it is a little more doubtful what the result will be. They haven't the chance to vary the composition and depend more upon the raw material.

Mr. Moses. — I might say in regard to Bessemer steel: These eye-bars in the Boylston Street Bridge were Bessemer, and some other Bessemer eye-bars, bought about the same time and used for the Fitchburg Road, were subjected to an unusual test. They were struck by a train in a derailment, and the eye-bars, some of them, were bent edgewise at an angle of 45 degrees — practically a sharp angle — without a sign of fracture. The heads in that case were split open, but that wasn't surprising considering the blow they got. But the bars stood this strain as well as any open-hearth steel could do. I doubt whether Bessemer or open-hearth has much to do with it. It is probably safer to manufacture by the open-hearth process. There is Bessemer steel that will probably stand as well as open-hearth steel. I don't know what causes these hard places in the steel, but we do find them. I have known a plate 2 ft. wide to split into two layers. They don't generally split until you come to manufacture them. You find it out then. You can't punch them without splitting them.

The President. — I think the danger of shock is further illustrated by the fact that almost all railroad rails are Bessemer up to the present time. Perhaps in the future they will be open-hearth, but they have stood the test pretty well.

Professor Spofford. — In connection with my remarks upon Bessemer steel, it seems to me that the whole question of Bessemer steel as compared with open-hearth consists in the

greater uncertainty of results. You may get good tests of Bessemer steel, but it doesn't follow that all the rest of the output will be good. The results are not as uniform as with the open-hearth process. The open-hearth is supplanting Bessemer very rapidly in structural work, and even Sir Henry Bessemer thinks himself that he should have continued his experiments in open-hearth instead of going off and developing the Bessemer process. I looked at the tests of Bessemer steel in examining this bridge, and I realized that it was good Bessemer steel. But I am not in favor of Bessemer steel for structural work. The unit stresses were such that it wasn't wise to keep the bridge as it was, even if it was built of open-hearth steel. Still, to my mind, the fact that it was built of Bessemer steel was another element against it.

THE PRESIDENT. — I would ask Mr. Fay if he made any calculations as to the maximum unit stress ever developed in those corroded bars?

MR. FAY. — Such calculations have been made, Mr. President, and with a very small, uniformly distributed load of, say, 20 lb. per square foot of floor, and with only a single 26-ton car on each track — and we frequently get two cars on that bridge on each track — we found a number of instances in which the stresses must have been in the neighborhood of 20 000 lb. or so. That, however, is for an extremely small load. There was one instance where one bar, to which I did not call attention, was bent so it could not carry the normal stress; its mate in that particular panel was carrying a stress even under this small load of 43 000 lb., assuming that it was doing half the work of the double truss. I should say that probably the actual stresses obtained in the diagonals under everyday traffic, with the car tracks full and with the roadways reasonably full of teams, and the sidewalks having such foot travel as is likely to come on the bridge, might easily have reached 30 000 lb. in many cases. And, of course, in the particular case where there was a bent bar out of service in a panel, the stress must have been very much higher. But the stresses in those diagonals were not as high as you might think, because, as Professor Spofford said, many of the diagonal bars had an excess of section originally.

[NOTE. — Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by March 15, 1910, for publication in a subsequent number of the JOURNAL.]

THE ENGINEERING TRADES ON THE PACIFIC COAST.

By George W. Dickie, Member of the Technical Society of the Pacific Coast.

[Read before the Society, November 26, 1909.]

For some time I have felt growing upon me the necessity of writing a paper on the above subject; to me the subject is not an agreeable one, nor is it likely to be so to most of those who may listen to me read this paper or read it themselves afterward. My connection with the engineering trade on this coast began in 1870, and still continues. During that period of nearly forty years, mining machinery and marine engines for our coastwise shipping formed the most important work for our engineering establishments.

The development of the mining industry of California and Nevada brought to the mechanical engineers of the state many problems requiring much original mechanical work in their solution. The treatment of ores required the combination of mechanical skill and chemistry to solve the problems involved, and the many contrivances designed and made here for the extraction of the precious metals from their native matrix of rock made the foundries of San Francisco famous for the machinery required in the treatment of all kinds of ores.

Hydraulic mining, which required large quantities of water to be carried sometimes under great pressure, and at a cost that would make it profitable as a means of dislodging and disintegrating huge masses of earth and gravel, originated the building of riveted iron pipe and the making of the powerful hydraulic nozzles called "giants."

The utilization of mountain streams, where the pressure was more in evidence than the volume, forced the hydraulic engineers into devising simple but effective water wheels that have made water power possible in many regions of our mountain ranges where it was not so by any of our then existing methods.

Between 1870 and 1880 hoisting and pumping works for deep mining were developed in our engineering shops to a remarkable degree, both in size and efficiency. Air compressing also for deep working received much attention from our mechanical engineers; the first two-stage compressors were built in San

Francisco. In marine engineering the progress was equally swift; the first triple expansion engine built in the United States was built here. The first quartz mill that went into South Africa was a product of our designing and constructing skill.

Thus it will be seen that during the last thirty years of the nineteenth century there was no lack of engineering enterprise amongst us, but during the past ten years there has been a great falling off in the mechanical engineering work done here.

Establishments that employed thousands of men are practically fallen into idleness, while the machinery importing houses have enlarged their business and are not only selling machines produced in other states, but are planning and carrying out machinery installations that were not considered within their scope a few years ago. The suddenness of the decline, and in some instances total extinction, of what were flourishing industries a few years ago has bewildered many of those who looked upon these industries as a permanent part of the achievement, resulting from sixty years' endeavor, of the able men who brought them into existence.

The writer began to see the dangers confronting these industries about 1896 and warned those interested. The first symptom was a general condition of unrest among the men; wages were higher here than in any other state, — at least as much higher as to make up for the cost of transportation of machinery made elsewhere, — yet the leaders were able to persuade the men that any demands they made would be allowed after a show of fight. In this way their minds were poisoned to such an extent that for several years, or up to 1901, the conditions were very trying. Men became indifferent, and what work they did, like all work forced from unwilling hands, was badly done and cost much more than it did when the men were doing it under normal conditions; this prevailed to such an extent that the great strike of 1901 was accepted by the employers as a relief from conditions that had become intolerable. This strike in the metal trades lasted about eleven months and both sides were exhausted; neither side ever fully recovered. A large part of the business that naturally belonged to San Francisco engineering works went permanently into the hands of the commission houses representing establishments in the other states, which could lay down machinery here, with freight and commission added, at less cost than it could be made for here. This condition has been aggravated by the conditions following the disaster of 1906, the efforts to recover from which, while demonstrating the

courage of our citizens, has still further intensified the difference in cost of manufacturing here as compared with other states.

The opening of the Panama Canal will have an important influence on the cost of transporting machinery from other states where it is manufactured under different conditions, economic and otherwise. This event will be powerful in forcing conditions here into correspondence with conditions in other states; either this correspondence will ensue, or engineering establishments on this coast will have to be abandoned. It is to be hoped that another destiny awaits us as the future opens up opportunities, and that some way will be found to enable us, those who work with hand and those who work with brain, to unite in some method whereby we shall be able to produce work of all kinds as cheaply as other states of the Union, under conditions that will raise the status of the workman and at the same time give remunerative employment to the brains and capital of our people.

In the Eastern states much has been done of late among the metal trades to render the workmen more efficient and thereby increase their product. The principal improvement has been in the science of cutting metals. The high-grade steel now used in the construction of machinery has brought about a great change in the methods of shaping the blanks that come from the forge. Fine smithing is no longer profitable, and rapid cutting has taken the place of skillful hammering. A great many of the establishments in the East have adopted tools and methods of handling them that leave us far behind. The progress made of late years in the art of cutting metals is one of the marvels of this age of steel. In this country no one has done more to develop the science of metal cutting and the art of applying it in the shop than Mr. Fred W. Taylor, of Philadelphia. In this work he has been ably seconded by such men as Mr. Barth and Mr. Gantt. After an immense amount of labor and experiment, extending over several years, these men have been able to produce practical solutions of the mathematical problems growing out of the laws governing the effect on the final result of the conditions under which the work is done.

Mr. Taylor gives the following twelve variables that constitute factors in the problem of computing what should be standard time required for any task in machine work:

a. The quality of the metal which is to be cut, that is, its hardness or other qualities which affect the cutting speed.

b. The diameter of the work.

c. The depth of cut or one half the amount by which the forging or casting is being reduced in diameter in turning.

d. The thickness of the shaving, or the thickness of the spiral strip or band of metal which is to be removed by the tool, measured while the metal retains its original density; not the thickness of the actual shaving, the metal of which has become partly disintegrated.

e. The elasticity of the work and of the tool.

f. The shape or contour of the cutting edge of the tool, together with its clearance and lip angles.

g. The chemical composition of the steel from which the tool is made and the heat treatment of the tool.

h. Whether a heavy stream of water or other cooling medium is used on the tool.

i. The duration of the cut, that is to say, the time which a tool must last under the pressure of the shaving without being reground.

k. The pressure of the shaving or chip on the tool.

l. The changes of speed and feed possible in the lathe.

m. The pulling and feeding power of the lathe or other machine at its various speeds.

The effect of these twelve variables upon the following three questions, directly affecting the economy of the shop, was the problem to be solved:

What depth of cut shall be used?

What feed shall be used?

What cutting speed shall be used?

It required years of experiment before sufficient data were collected to enable these questions to be approximately answered and the mathematical problems reduced to the scope of a special slide rule that could be used in the every-day shop work.

Out of this research has grown what is known as the instructor, task and bonus system, which has been adopted with very satisfactory results on the economy of production by many shops in this country. A manager who understands and can use this system is enabled to determine the possible work that he can get out of every tool in his establishment and to determine on the best tool to get when he adds to his plant. The majority of people, however, including managers, foremen and workmen, prefer to work at the speed and in the manner they have been accustomed to, and it requires some kind of stimulus to change the methods that are in use.

The inertia of men in all departments of an engineering

establishment, from the manager down to the humblest laborer, is the principal object that stands in the way of any system that demands continual alertness in making the most of every minute of time; hence the necessity of a bonus or reward for every one interested when the task that has been set after careful experiment has been accomplished; but in reaching the standard time required for any job or task, the possibility of rapid accomplishment must be demonstrated in detail to the workmen by an expert who can actually do every part of the task within the standard allotment for each part. This man is the instructor. When a workman succeeds in completing his task within the time set for it, he is entitled to a bonus, which is usually from 20 to 50 per cent. of that time; if he takes more than the allotted time, he gets only his regular pay. In setting these tasks it is customary to specify the manner of performing all the operations and to supply the proper tools to the workman; this requires a highly trained staff to insure success. Mr. Gantt claims that when 25 per cent. of the workmen are bonus men, they, with those who are striving to become bonus men, control the sentiment and a strong spirit of coöperation develops, and this spirit of living up to the standard set by an expert, which is the only way that a bonus can be earned, benefits the employer by the production of more work, better work, cheaper work; it benefits the workmen by giving them better wages, increased skill, better habits of work and more pleasure and pride in their work; this latter benefit to the employee is even more of a benefit to the employer, for it insures good work.

This system has been extensively adopted in the Eastern states and has generally resulted in a larger and better product produced at lower cost, while the earnings of the workmen have been increased.

That the system outlined above can be adopted in the engineering shops on the Pacific coast is open to argument. Where manufacturing is done on such a scale that thousands of the same piece have to be produced, giving an opportunity for careful experiment to determine what should be the standard time for its production, and where the cost of such experimenting and the expert's time would form a very small percentage of the cost of production, such a system will show great economical advantages; but where new problems come up every day, and manufacturing in the sense of duplicating parts by the thousand does not exist, the system so successfully developed by Mr. Taylor and his associates will not show any advantage; this latter

condition is the prevailing one on the Pacific coast, where, under present conditions, it is impossible for our shops to compete in any line of business that can, because of wider markets, be carried on in the East as manufacturing.

The system is also defective because it cannot be applied to the general work of a shop, except, perhaps, in the assembling of small machines that involve only the work of one man on each task, or subdivision of the work involved; where the assembling of large machines, or engines, involving the work of many hands, forms a large part of the work of an establishment, the task and bonus system cannot be applied, for it would be impossible to compute a standard time for each workman and set him a task; in such cases a standard would have to be set for a number of men collectively, and should they fail to meet the standard set, they would collectively lose the bonus, although individually they might each have been capable of doing their proportion of the task. I believe that the application of this system must be largely, if not entirely, confined to the work done on machines that are especially adapted to the work in question, and where the work is the duplication, in large numbers, of pieces that can be standard in form and dimensions and also in quality of material.

A knowledge of the working of such a system should, however, be of great value to the manager of a general engineering works, as it would enable him in making estimates of the cost of work to determine, with some approach to exactness, what should be the possible efficiency of his tools on different classes of work; a careful study of what is possible for every tool, and every man in the establishment should be always available to the manager of an engineering shop if he is to keep abreast of the possibilities that lie within his management. Such knowledge is worth much labor and experimenting to find out, and is really the foundation of all correct estimating.

The tool part of this problem, in conjunction with the operator, is, with our present knowledge, — thanks to Mr. Taylor and others in the same field of research, — to a certain extent solvable. The cutting power and endurance of tool steels, the possible speed under known conditions, the pulling power of belts, how these are affected by the character of the material operated on, and all the variables that enter into that part of the problem, the labors of such men as Taylor, Gantt, Barth and others have brought within the scope of the ordinary manager's ability, and they can be figured out with a reasonable degree of accuracy.

But how about the other men that don't work with tools that have known speeds and adjustable feeds? In the general engineering works they outnumber those on tools at least three to one. The work of this other man is the unknown quantity in all estimates of labor; the only certain thing about him is his rate of pay per hour or day, the work to be accomplished being an unknown quantity and the purchase of the man's time being only an option on something the amount of which will only be known after delivery. As the labor part of any estimate for machinery will be from 40 to 80 per cent., depending upon the simplicity or complexity of the work, and as the rate of wages is considerably higher than it is in the Eastern states, and with a much more contracted market, cutting out manufacturing in the economic sense, how is it possible for our engineering establishments to reach and maintain a satisfactory place in the industries of the Pacific coast?

From a long experience and after much study I reached the conclusion some fifteen years ago that there was only one solution to this problem if such industries are to live and prosper, and that lies in an entire change of attitude towards each other, of the employer and the employed. They must become partners in the labor part of every estimate. The advancement in general education, with the opportunities open to every one for acquiring knowledge relating to technical subjects, enables the workman to understand estimates made for the work they are engaged in. I think that it is safe to say that from a body of workmen employed in any of our engineering establishments there could be selected men to represent the body to which they belong that would, in a very short time, be just as competent to estimate on the labor cost of machine work as the manager of the works or any other officer that does the estimating; they would really have the advantage, for they can, in a measure, make the result fit the estimate. It is an evident fact that any machinery made on this coast to compete with the same machinery imported from other parts of the country must be produced for the same cost, plus freight charges, and must be sold here at the same price; and as transportation cheapens, which it will do materially on the opening of the Panama Canal, the conditions will be worse than they now are, unless the labor costs can be equalized between the East and the West. In all classes of machinery that have to go into general competition, the price obtainable here is easily known. The manager of any of our engineering establishments knows, or ought to know, what the materials required for the

production of any given piece of machinery cost; he knows, or ought to know, what the percentage of general expense or overhead charges, which includes cost of management and every other operating cost not charged directly to this particular thing, is. He knows what per cent. he must add for profit. But the largest item — the cost of labor — he must assume from his experience, which may mislead him. And the trouble here to-day is the inability of those operating engineering works to establish the cost of labor. I used in estimating, of which I have done a great deal, to divide the work to be estimated on into as many units as possible, the more the better; then take each unit and carefully figure out the hours' work that would be required on the various operations to complete it — going on my own knowledge and the record of other work that came near it in character; then I would group these units into a part that would appear in the estimate as a distinct portion, that could be placed in the shops under a special number and its actual cost compared with the estimate. In that way many years of experience enabled me to estimate closely, when conditions were constant, which of late years have been far from the case. Many a time I have watched the progress of some piece of work, comparing it regularly with the estimate. I would often go to the leading man when the cost would come dangerously near my estimate and say something like this to him: "Jimmie, when will you get done with this, and can't you reduce the force and do just as well?" To which he might reply, "I think, Mr. Dickie, we will be able to complete this job to-morrow," and I would go away, satisfied that my estimate was all right, dismiss it from my mind, and I might not see the job again for a week; but just as likely as not when I did see it again, Jimmie and his gang would be still at work on it and my estimate all gone to smash. Now why should not Jimmie and his gang have something to say about the cost of labor for that job and agree to accept that cost as their compensation at the time the estimate is made? In other words, I would suggest the system for the Pacific coast that I have long advocated as a means of enabling our shops to meet the outside competition, — that of taking the workmen, or their representatives, into counsel when the estimates are made for any work, and have the men or their representatives, when satisfied with the estimate for labor, accept the amount so estimated as the amount that would be paid to the workman for all the labor included in the estimate. This would extinguish the wage question, and with it the uncertainty in regard to the outcome of

any contract, and would give capital the necessary confidence to engage in the work of producing here the machinery needed on this coast. It would avoid all fighting with the unions and the loss and distress entailed thereby. I have pointed out what is being done in other parts of the country to insure a known output from a given number of men and tools. A knowledge of that work would be a great help to the manager of works here, and perhaps more so to the men, who, if they are to abide here and live by the work they have been trained to do, must find a way to do their work at such a cost as will enable those having work to do to place it in the works that gives them employment. I have described my plan in detail elsewhere and need not go into details here. Briefly it is this: The men in each department of the works would select one of themselves to represent them in contracting for work. These men would be chosen for a certain time, say one year; that is, there would be an opportunity for change every year. So that the best men in each department would form the Works Committee in all dealings with the office, and a contract signed by them would be binding on all the men. This committee would also rate all the men in the various departments, the rate in no case to be more than the prevailing rate of the district.

In making all estimates for work, the factors forming the estimate should be:

First: The actual cost in the works of all materials required for the work being estimated on.

Second: The general expense to be borne by the work in question. This includes all actual costs not charged directly to specific work, such as expense of operation, management, maintenance of plant, power, interest on borrowed money (not capital), taxes, advertising, foremen and all men, such as watchmen, sweepers, etc.; in fact, everything not charged directly to the work in progress, the item known as overhead charges. The *pro rata* of this charge would be the proportion that the work being estimated upon would bear to the average year's output.

Third: The actual cost of labor which the manager would estimate on, according to his experience, which would be carefully gone into by the workmen's committee, and, if necessary, changed in accordance with what was mutually agreeable; and, when satisfactory, the total amount of this item would be the sum to be paid to the men.

Fourth: Profit, which would be a percentage on the sum of the three foregoing items. This percentage should be known

to the workmen's committee and they should be satisfied about it.

It might be that the sum total would be more than in the judgment of the manager would secure the work; in that case he would call in the Workmen's Committee and explain his reasons for thinking their price would not secure the work, then arrange either to deduct something from the labor cost, or the profit item, or both, as might seem best, or decide to let the work go elsewhere.

When work was secured, the contract for the labor item would be signed by the committee and its amount posted up in the works; the amount for labor would be credited on the books to the labor account; payments would be made to the men monthly, or as might be considered best mutually, these payments to be on the wage rate fixed by the committee less 10 per cent., each man's time being kept, as is the present custom, and the amount thus paid out charged against the amount of this contract in the labor account book. On the completion of the contract, the amount remaining would be carried over to the labor surplus account, from which dividends would be paid from time to time, the dividend being a percentage on the amount that each man had been paid in advance wages.

By this system the earnings of any man do not depend on any job, but it is the share of the surplus from all the work done during the year or six months that the dividend period covers. It would meet the idea of the trades unions that the strong should help the weak. It gives to every man the dignity of a contractor. The trades unions would then be able to perform a great and beneficent work, and labor would always have the chance to meet or not meet the price that the market and the times afford. Every man would be directly interested in the product of himself and his fellow-workman. It would not be like the task and bonus system, where a man must reach and pass a mark that has been set for him in order to get anything more than the prevailing rate of wages; but whatever he or his fellow-workmen may do that is better than the estimate will help to swell the dividend. Something like this is the only hope I see for the future of the engineering shops of the Pacific coast. We must produce work here at a cost that will keep our own markets, and it can only be done by the labor and the capital going into partnership to do it. Only those who have been in the fight and know what a struggle it is can understand what such a system would mean. The employers, I think, might hesitate to take the men they have been fighting so long into counsel with them

as to the cost of work. I do not believe such confidence would be misplaced, and it is the only way to bridge the gulf that lies between them, and without such bridge there is no crossing, and no hope for the future of our industries here. I should not expect any opposition from the trades unions to such a plan. They must realize that unless a change takes place there will be a continued and increasing depression in the engineering trades here until everything we require in the way of machines will be imported from other parts of the country. There is no reason why we should not be able to hold our own on the Pacific coast in all the engineering trades, but in order to do so the men who plan and direct and finance must join hands in a close partnership with the workman. one and all having the same purpose in view: our own work for our own shops. Such a combination will make it possible for the other party, the man who orders the work, to have his motto also: My work goes to the shop at home.

[NOTE. — Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by March 15, 1910, for publication in a subsequent number of the JOURNAL.]

DISCUSSION OF PAPER BY WILLIAM H. BRYAN, "GOING VALUE AS AN ELEMENT IN THE APPRAISAL OF PUBLIC UTILITY PROPERTIES."

(VOLUME XLIII, PAGE 147, OCTOBER, 1909.)

MR. S. BENT RUSSELL. — The author shows that "going value" has been officially recognized in appraisals both in case of those for purpose of sale and those for fixing rate. From the tenor of the paper it is pretty clear that the author has no bias against the allowance of "going value." He has, nevertheless, failed to present any good argument in favor of using "going value" as a basis of rates. His quotation from the Wisconsin decision on page 149 is by no means convincing in itself. Moreover, when we view it in the light of the author's subsequent discussion in regard to cost of producing income, we find its argument has no leg left to stand upon.

To make the point clearer, the Wisconsin authorities will allow "the actual reasonably wise expenditure of money towards getting the business of the plant established" (p. 149). If that were all, the ruling would almost stand unchallenged, but in the same paragraph we find the bars let down so that it seems a case of making the "going value" stand in inverse ratio to the income. Moreover, and on the other hand, we find that the author on the same page (149) states that it is not a question of what has actually been expended.

Again, in a subsequent statement (fourth paragraph, p. 153) the author indicates the futility of trying to find "the increased worth of the present system" from the income for rate revision. And this seems to be the author's view where rate revision is the object, even if a hypothetical fair income be substituted for the actual income.

In short, it appears that the author would make an appraisal rest on present value based on cost of reproducing, and can show no clear way of computing the cost of reproducing income that would be admissible as a basis for rate making. To put it another way: he apparently finds that the cost of reproducing an established business cannot consistently be coupled with the cost of reproducing the physical property in determining rates.

We may fairly conclude that the author has been able to find no logical justification for the use of "going value" as a basis of rates. May we not further conclude that the only sensible basis for rates is the physical or tangible value of the property?

As the "fair return" is an allowance that, within the limits set by custom, must be arbitrarily assumed, why apply it on a present value also arbitrarily assumed as it seems "going value" must largely be? May not the "fair return" be made great enough to recompense the parties concerned for all effort in obtaining business after the plant is ready to operate?

Reply of the Author to the Discussion of Mr. Russell. — The author has certainly no bias against the admission of "going value" in appraisals. The necessary cost of building up any business is as much a legitimate part of the investment as is the plant itself, and the earnings should carry and in time repay this, the same as other items of cost. The author accepts the definition of "going value" as the present cost of duplicating the present business. But he confesses to grave uncertainty as to the best method of estimating this cost. No suggestion yet made is free from objection, although the tentative or "cut and try" plan on page 151 seems best. The author welcomes Mr. Russell's concurrence in the plan pointed out near the bottom of page 151, that rates be fixed so that the resulting "fair return" would cover the cost of getting the business, i. e., the "going value." This is exactly what intelligent rate fixing should try to do.

Mr. E. W. Bemis. I have read with much interest Mr. Wm. H. Bryan's paper. I like the provision of his contract given on page 158, which he drew for a water works at Mexico, Mo., which provided that the city might purchase after fifteen years at "the then cost of duplication less depreciation of said property with 10 per cent. additional thereto as compensation for earning power, franchise value, going value, contingencies and all other tangible values of every nature whatsoever."

In order, however, to make the meaning still clearer, I would suggest that he add promoters' profits, development expenses, interest during construction, cost of financing, legal expenses, insurance, engineering administration, supervision and all other matters not appearing in an inventory of property in use. The above I would insert after his word "contingencies" in his Mexico contract. It is evidently his thought, but one cannot err by being as specific and all-embracing as possible.

I hold further that the principles to be adopted in appraising a plant which has not such a provision, but whose franchise has expired, is not the cost of duplication with all these elements in it, but the value that one can see in an inventory plus perhaps 10 per cent. or 15 per cent. If the franchise has expired and if the plant has been fairly profitable, it should have amortized all the other expenses, and probably has done so out of earnings in the previous years.

OBITUARY.

Edwin William Ellis.

Member of the Boston Society of Civil Engineers.

Edwin William Ellis, son of George and Esther (Muir) Ellis, was born in Middleboro, Mass., February 13, 1874. He was educated in the public schools of Pawtucket, R. I., graduating from the grammar school in 1889 and continuing his studies in mechanical drawing, in the evening schools, from 1890 to 1894.

In 1889 he entered the office of J. A. Latham, of Providence, R. I., serving an apprenticeship of three years, and continuing with him until 1894. He then worked as transitman with J. E. Judson, at Pawtucket, R. I., until October 3, 1894. He was employed for different periods by Arthur J. Patten, at Waterbury, Conn., and by the Benjamin F. Smith Company, at Pawtucket, R. I.

He entered the city engineer's office at Pawtucket, R. I., May 9, 1898, and was employed there until December 28, 1901, as assistant and draftsman. Coming to Boston in 1902, he entered the employ of E. W. Everson & Co., contractors, as civil engineer on tunnels, sewer, heavy foundation work, brick and stone masonry, and road building. During the summers of 1905 and 1906 he was employed by the Water Board of the city of Cambridge as inspector and foreman on the construction of a large concrete conduit. From October 21, 1905, to January 26, 1906, and from December 22, 1906, to November 30, 1907, he was employed as inspector of masonry in the Engineering Department of the city of Cambridge, on bridge foundation work. From April 9, 1908, to October 27, 1908, and from May 10, 1909, until his death, he was in the employ of the Charles River Basin Commission, first as inspector of pile driving and masonry and later on the finishing of the Boston embankment.

Mr. Ellis became a member of the Boston Society of Civil Engineers on January 24, 1906. He died of appendicitis August 3, 1909, at the Boston Homœopathic Hospital. He leaves a brother and cousin as his only near relatives.

In his work he was thoroughly honest, conscientious and loyal to his employer, whether contractor or corporation, and had unusual skill and tact as an inspector in securing results without unnecessary friction or contention. In handling men on construction work, his skill and judgment were unusually good.

Of a simple, modest and retiring disposition, Mr. Ellis was not well known by a large number of the members of this Society. To those who became acquainted with him, however, these qualities appealed very strongly. Those who knew him best, liked him most. He seemed to have the quality of tact, which is all too rare among engineers, of securing and retaining the respect and esteem of all with whom he came in contact.

L. M. Hastings,
John N. Ferguson,
Committee.

ASSOCIATION

OF

ENGINEERING SOCIETIES.

VOL. XLIII. JULY, 1909. No. 1.

PROCEEDINGS.

Technical Society of the Pacific Coast.

SAN FRANCISCO, JULY 16, 1909. — A regular meeting of the Society was held on July 16, 1909, at the Hotel Argonaut, where dinner was had before the business of the meeting was taken up.

President George W. Dickie presided.

The minutes of the last regular meeting were read and approved.

The Secretary stated that owing to his recent illness certain matters had been postponed and necessarily delayed, but that now the regular business of the Society would take the usual course, from month to month, without any interruption.

The following candidates, who have applied for membership at the last regular meeting, were duly elected by a vote of the members present:

Mr. Bruce Lloyd, vice-president of the Ker-Lloyd Iron Works, San Francisco; Mr. Charles E. Ker, president of the Ker-Lloyd Iron Works, San Francisco; Mr. O. Jacobsen, mechanical engineer, San Francisco.

Mr. B. J. S. Cahill addressed the Society on an important municipal subject entitled, " A Civic Center for San Francisco."

This paper was discussed by the members present, and ordered to be submitted to the Secretary to be prepared for publication in the JOURNAL OF THE ASSOCIATION OF ENGINEERING SOCIETIES.

The meeting thereupon adjourned.

Attest,

OTTO VON GELDERN, *Secretary.*

ASSOCIATION
OF
ENGINEERING SOCIETIES.

VOL. XLIII. AUGUST, 1909. No. 2.

PROCEEDINGS.

Louisiana Engineering Society.

Synopsis of Work Done, January–June, 1909.

AT the annual meeting on January 9, reports of all officers and committees were read, and officers for 1909 were elected. Mr. C. W. Wood delivered the address as retiring president.

The meeting adjourned to the banquet, arranged by chairman J. F. Coleman, at Galatoire's, and a most enjoyable evening was spent by the members.

The Board of Direction, at their meeting of January 16, created an Advertising Committee to solicit advertisements to the Journal. The committee, under the able chairmanship of Mr. Paul L. Brand, did some successful work.

The Society, at its meeting on February 8, authorized the Library Committee to properly catalogue and index the library. This committee, with Mr. J. W. Armstrong as chairman, has accomplished excellent results. A competent cataloguer was employed to do the work, and we now have our entire library, as well as the engineering literature contained in the three large libraries of the city, namely, the Howard, New Orleans Public and Tulane University, card indexed, and the books of our library shelved, all according to the Standard Dewey System of Cataloguing. This gives our members a ready reference to all engineering works contained in those four libraries, and provision will be made to keep this system up to date.

The Future New Orleans Committee was reorganized. This committee has employed a draftsman, who is now engaged in making a map of future New Orleans, as designed by the committee, for 1 000 000 inhabitants.

On March 8, Prof. W. B. Gregory, member Louisiana Engineering Society, read a paper on the "Test of a Gas Compressor."

On April 12, J. W. Armstrong, member Louisiana Engineering Society, gave a description of the intakes of the new water works systems for both New Orleans and Algiers.

On May 10, the Society created an honorary roll of membership, by an amendment to the Constitution. Prof. John M. Ordway was elected an honorary member at this meeting.

Mr. Lyman C. Reed, member Louisiana Engineering Society, read a paper entitled "Heat, Its Use and Distribution."

On June 14, the Society postponed the outing until fall.

The McKinley Congressional Bill, providing for the establishment of engineering experiment stations at land grant colleges, was endorsed.

Mr. Alfred F. Theard, member Louisiana Engineering Society, read a paper on "Chalmette Monument, Its Recent Enlargement."

The Society decided to adjourn for the months of July and August.

L. C. Datz, *Secretary.*

Association of Engineering Societies.

Vol. XLIII. SEPTEMBER, 1909. No. 3.

PROCEEDINGS.

Montana Society of Engineers.

Butte, Mont., May 8, 1909. — The May meeting of the Society was held on the above date, with a quorum present, and President C. H. Bowman presided. The minutes of the last meeting were read and approved. The application of Wm. J. McMahon for membership in the Society was read, approved and the regular ballot ordered. Messrs. Inch and Morris were elected members by a unanimous vote. Prof. F. W. Traphagen and Mr. Kilgore, of the Colorado School of Mines, were present and the chair appointed Messrs. Moore and Hobart as a committee to confer with Professor Traphagen about entertaining the Colorado students visiting Butte.

The chair appointed a program committee for the balance of the year. Said committee consists of Messrs. Moore, Pope and Hobart. Mr. H. H. Cochrane gave a very entertaining and instructive talk on the various kinds of electric lamps in common use, after which the Society adjourned till the September meeting.

Clinton H. Moore, *Secretary.*

Butte, Mont., September 11, 1909. — The regular meeting of the Society was held on the above-named date in accord with the action taken at the May meeting. President C. H. Bowman presided. The minutes of the May meeting were approved as read. Wm. J. McMahon was elected to active membership in the Society. The Committee on Program recommended that Mr. James H. Ellison be invited to furnish a talk or paper on "The Taft Tunnel Project," and the Secretary was instructed to extend the invitation to Mr. Ellison. The resignation of F. A. Schiertz was presented and accepted. The chair named the following committee on nomination of officers for next year: Messrs. Carroll, Dunshee and Evensen.

Adjourned.

Clinton H. Moore, *Secretary*

Louisiana Engineering Society.

MEMORIAL RESOLUTIONS.

(Adopted September 13, 1909.)

ON THE DEATH OF PROF. J. M. ORDWAY.

Whereas, our esteemed friend and the only honorary member of our Society, John Morse Ordway, has been removed from our midst by death; be it

Resolved, that the members of the Louisiana Engineering Society, in regular meeting assembled, express their deep sorrow at the loss of Dr. Ordway, and further express their full recognition of his high character as a man and a scholar.

His long life was devoted to the advancement of the arts and sciences, and his attainments in the field of technical education and industrial chemistry were of the highest order.

His ten years as an active member of our Society showed a devotion to its interests and welfare that was always an inspiration to his fellow members.

Resolved, that these resolutions be spread upon the minutes of the Society, and a copy thereof be sent to the family of the deceased.

ON THE DEATH OF MAJOR H. B. RICHARDSON.

The Louisiana Engineering Society records its deep sorrow at the death of its member, Major Henry B. Richardson, and its appreciation of his services to the state and of his qualities as a citizen, an engineer and a friend.

Major Richardson was one of the first to enlist in defense of the South during the Civil War, through which he served as an engineer with great distinction. His service was eminently valuable from a faculty for rapid, daring and accurate reconnaissance.

While possessing a breadth of knowledge and experience fitting him for the general practice of the profession, he chose for his life work the study of alluvial rivers, and particularly of the Mississippi and the reclamation of its alluvial valley from overflow.

The predominating interest of Louisiana in this work, his close and alert power of observation, his sound conclusions, his firmness of resolve and his long experience, covering the four decades during which the system grew from a frail barrier, breached by every flood of more than average height, to its present dimensions, all mark him as probably the principal contributor in this great work of reclamation.

The evidence of the value of his service and the absolute confidence which he had acquired is his retention of his high office, which was subject to change with every incoming administration, for twenty-four years, or until he resigned to enter the service of the general government as a member of the Mississippi River Commission. He was incapable of entering any selfish contention for personal promotion, and work and fame came to him only as the logical result of proved character and capacity.

We all here knew him as the modest, unselfish, wise, firm and courageous gentleman, the distinguished engineer, the true friend.

The Club begs to extend its warmest sympathy to his widow and the other surviving members of his family.

Utah Society of Engineers.

Salt Lake City, Utah, September 18. — The meeting was in the nature of a house-warming and smoker in order to formally open the Society's new headquarters in the Newhouse Building. An initial equipment of furniture has been furnished and the rooms supplied with back files of eighteen technical and engineering periodicals.

Under the head of reports of committees, Secretary McNicol, as chairman of the Program Committee, reported that arrangements had been made for the presentation of several timely and interesting papers during the coming season, completed list to be announced later when dates have been assigned.

The matter of entertaining the members of the mining engineers returning East from Seattle was discussed at some length and a committee was appointed with Mr. Ben. F. Tibby as chairman to devise ways and means of conducting the visitors through the various mining camps of the state while they are here. It is expected that there will be one hundred visiting mining engineers in the city from October 5 to 9.

Delegates were appointed to represent the Society at the Goldfield Mining Congress.

The following gentlemen were elected to membership in the Utah Society of Engineers: George M. Bacon, Anders Bagge Villadsen, Jens Martin Villadsen, Henry C. Hoyt, L. Douglas Anderson, Charles Ulrich Heuser.

Applications were presented from the following: Alexander Grant McGregor, Joseph Ulmer, Henry Denison Randall, Markham Cheever, all of which will be acted upon at the next regular meeting of the Society.

Attendance, 43.

A special meeting was called September 30 for the purpose of extending a formal reception to Mr. Ralph W. Pope, Secretary of the American Institute of Electrical Engineers. Addresses were made by President Jos. F. Merril, Leonard Wilson, John C. Jones, D. McNicol, A. G. McGregor, O. H. Skidmore, A. L. Woodhouse and City Engineer L. C. Kelsey. Mr. O. A. Honnold acted as chairman of the meeting.

In response to the speeches of welcome, Mr. Pope gave a very interesting account of the workings of the Institute, and of the objects of his mission. Mr. Pope was on his way back from Seattle where he attended the electrical festivities of the Alaska-Yukon-Pacific Exposition. Mr. Pope remained in Salt Lake City five days, during which time he was taken to the various hydro-electric plants throughout the state.

D. McNicol, *Secretary.*

Association of Engineering Societies.

Vol. XLIII. OCTOBER, 1909. No. 4.

PROCEEDINGS.

Engineers' Club of St. Louis.

St. Louis, May 19, 1909. — The 670th meeting of the Engineers' Club of St. Louis was held at the Club rooms, 3817 Olive Street, on Wednesday evening, May 19, 1909. President Wall presided. There were present twenty-three members and five visitors.

The minutes of the 669th meeting were read and approved. The minutes of the 464th meeting of the Executive Committee were read.

Mr. Roy A. Campbell was elected to membership. Applications for membership from Mr. Robert H. Brown and Mr. Ernest W. Pittman were read.

The Secretary read a letter from the Board of Freeholders asking that the Club name a representative or representatives to appear before it for the purpose of making specific recommendations. After some discussion, it was moved, seconded and carried that the Chair appoint special representatives, in response to the request of the Board of Freeholders, and that these representatives be requested to make such recommendations as may be indorsed by the Club, definite instructions to be given the representatives later. The Chair appointed Messrs. M. L. Holman and Robert Moore.

The Secretary read a letter from the Central Trades and Labor Union in which was set forth a series of resolutions drawn up by that body for the consideration of the Board of Freeholders, and requesting the Engineers' Club to endorse them. The matter was laid on the table.

Mr. W. H. Bryan, on behalf of the committee appointed at the last meeting to take up with the authorities at Jefferson City the bill for the regulation of the practice of architecture and the licensing of architects, reported that the bill had been killed and asked that the committee be discharged. There being no objection, the committee was declared discharged.

Mr. H. W. Whitten then presented the paper of the evening, on "The Effect of Air Leakage on Heating and Ventilation." The paper described the results of a series of tests on the amount of air leakage through window

frames of the ordinary type and also when provided with a special weather stripping; also the rate of heating and cooling of the air in a specially constructed compartment, provided with a window and arranged to be exposed to winds of varying velocity and direction.

The discussion following the paper was participated in by Messrs. Bryan, Whitten, Kauffman and Langsdorf.

On motion, duly seconded, it was unanimously voted to extend the thanks of the Club to Mr. Whitten for his courtesy in preparing the paper.

Adjourned.

A. S. Langsdorf, *Secretary.*

St. Louis, June 2, 1909. — The 671st meeting of the Engineers' Club of St. Louis was held at the Club rooms, 3817 Olive Street, on Wednesday evening, June 2, 1909, at 8.30 o'clock. President Wall presided. There were present twenty-five members and twenty-two visitors.

On motion duly seconded and carried it was voted that the Secretary cast the ballot of the meeting for the election of the following gentlemen whose applications had been duly approved by the Executive Committee: Robert H. Brown, Ernest W. Pittman. The Secretary reporting that this had been done, the two gentlemen named were declared elected to membership in the Club.

Col. J. A. Ockerson then presented a very interesting address, fully illustrated with lantern slides, on "Scenes in Russia and Other European Countries, and Scenes by the Way."

After the conclusion of the address the members and their guests, among whom was a large number of ladies, adjourned to the adjoining rooms where the Entertainment Committee had provided refreshments.

Adjourned.

A. S. Langsdorf, *Secretary.*

St. Louis, September 15, 1909. — The 672d meeting of the Engineers' Club of St. Louis was held at the Club rooms, 3817 Olive Street, on Wednesday, September 15, 1909, President Wall presiding. There were present twenty members and six visitors. In the absence of the regular Secretary the minutes of the preceding Club meetings and Executive Committee meetings were not read.

Mr. Wm. H. Bryan presented a memorial to Mr. William C. Eimbeck, a charter member of the Club, who died March 27, 1909.

The application of Mr. S. C. Baker for membership was read. President Wall presented to the meeting a proposition from the American Society of Mechanical Engineers to join with the Engineers' Club of St. Louis in holding joint monthly meetings. On motion duly made and seconded it was voted that the Executive Committee be given power to act in making arrangements with the American Society of Mechanical Engineers for such joint meetings.

Mr. J. B. Emerson then presented the paper of the evening, on "The Possibilities of Service from a Bureau of Inspection and Tests." The subsequent discussion was participated in by Messrs. E. Posselt, M. Schuyler, and John N. Ostrom.

Adjourned.

A. S. Langsdorf, *Secretary.*

Boston Society of Civil Engineers.

BOSTON, SEPTEMBER 15, 1909. — A regular meeting of the Boston Society of Civil Engineers was held at Chipman Hall, Tremont Temple, at 8 o'clock P.M., President George B. Francis in the chair; eighty-eight members and visitors present.

The record of the last meeting was read and approved.

The President announced the death of Edwin W. Ellis, a member of the Society, which occurred on August 3, 1909, and appointed the following members a committee to prepare a memoir: Messrs. Lewis M. Hastings and John N. Ferguson.

Mr. Holmes, for the committee to prepare a memoir of Charles D. Elliot, read its report.

On motion of Mr. Fay, the Secretary was directed to tender the thanks of the Society to those who had placed automobiles at the service of the committee appointed to entertain members of the American Society of Civil Engineers attending the Convention at Bretton Woods who might come to Boston. Cars were furnished by the Metropolitan Water Board, Mr. Charles S. Sergeant, Vice-President of the Boston Elevated Railway Company, Mr. Harry P. Nawn and by the following members of the Society: William L. Miller, Frederic P. Stearns, Frank A. Barbour and George A. Kimball.

The thanks of the Society were also voted to the officials of the Boston & Albany Railroad Company for courtesies extended this Society on the occasion of the visit of the members to the East Boston Terminal Improvements.

The paper of the evening was by Mr. James W. Rollins, Jr., and was entitled, "Building the Shut-off Dam at the Charles River Basin."

The discussion following the reading of the paper was participated in by Messrs. Harold P. Farrington, Frederic H. Fay and President George B. Francis. The paper and discussions were illustrated by lantern slides.

Adjourned.

S. E. TINKHAM, *Secretary.*

BOSTON, OCTOBER 6, 1909. — A regular meeting of the Sanitary Section was held at the Boston City Club.

The meeting was called to order at 7.30 P.M. by Chairman F. A. Barbour. Mr. Alexis H. French read a paper descriptive of the Brookline Comfort Station. Following Mr. French, Mr. Arthur D. Marble read a description of the Comfort Station at Lawrence. Both of these stations were novel in design, and the papers were illustrated with large scale drawings and photographs. Many details of design of such structures were described and methods and cost of operation were discussed.

Mr. Harvey, of the J. L. Mott Iron Works, discussed a few of the debatable points in connection with the plumbing fixtures for public purposes. Regarding the type of urinal, he stated that he preferred the long porcelain wall type to the individual bowl type on account of the better washing of the surface around and below the point of approach. He preferred glazed surfaces to marble partitions. Regarding closets, he said that the matter of flushing the water and the finish of the seat were matters ot debate. The integral seat, he said, was not a success. When

placed in institutions they were frequently covered with all sorts of wooden or textile seats. The seat having part of its circumference wooden and part porcelain is the latest device and is an effective compromise between the integral seat and the all-wooden seat. Mr. Harvey stated that a cleanly appearance is of the most importance in design of public comfort stations, where not only must the premises be kept clean, but must be so built that the presence of any dirt will be so noticeable that its immediate removal will be obligatory. In his opinion all general apparatus for flushing should be in a separate room. He approved of automatic seat flush tanks and believed that flush valves in connection with closets were fully as reliable as the ordinary flush tank and chain. Mr. Harvey said that the flush tanks appealed to him in cases where the closets were flushed frequently. In many places the period between usings does not permit the flush tank to completely fill.

Mr. Bunting described several types of fixtures which in his experience had proved to be most satisfactory. He did not like the siphon urinal of the Terminal Station type on account of the large volume of water contained in it permanently, nor the wall type on account of the liability of portions of the surface thereon becoming foul because of inadequate distribution of water.

Mr. Humphrey described " Kleen Spra " videt.

Messrs. Joseph Enright Conley and Joseph B. Stewart, Jr., were elected members of the Section.

About twenty-seven members and guests were present. In the afternoon the Section enjoyed an excursion to Brookline, where the comfort station, the new transfer station, the new water-works reservoir and also some deep sewer construction were inspected under the guidance of Mr. Alexis H. French, Town Engineer.

Robert Spurr Weston, *Clerk.*

Civil Engineers' Society of St. Paul.

St. Paul, Minn., October 11, 1909. — The monthly meeting of the Civil Engineers' Society of St. Paul was held in the Society's club room in the Old State Capitol Building, on Monday evening, October 11, 1909, with President H. J. Bernier in the chair. There were present nine members and seven visitors.

The reading of the minutes of the previous meeting was dispensed with.

The feature of the evening was to be a lecture on " Terminal Freight Handling," by Mr. H. McL. Harding, but, owing to his illness and inability to be there, a general discussion of the subject was participated in among those present, printed advance copies having been sent the members. This discussion was supplemented by a descriptive talk on the Spence portable electric conveyors, by Mr. W. W. Spence, of St. Paul.

It was then moved and carried that action on the applications of Messrs. A. J. Rasmussen and Paul K. Pulte, for full membership, Mr. F. Wm. Fiske, Jr., for junior membership, and the promotion of present Junior Member Mr. J. B. Mitchell to full membership be deferred at this time.

The meeting thereupon adjourned.

D. F. Jurgensen, *Secretary.*

Engineers' Society of Milwaukee.

Treasurer's Report for Year ending October 20, 1909.

RECEIPTS.

From E. P. Worden, ex-treasurer		$537.77
From fees and dues collected		897.00
Received on Gary account		441.50
		$1 876.27

EXPENDITURES.

Seven months' rent, Builders Club	$105.00	
Three quarterly assessments, Journal	169.00	
Printing and postage	121.50	
Paid on Gary account — excursion	525.00	
Refreshments	17.90	
Power Improvement Company, slides	50.00	
Furniture	40.90	
Stenographer	5.00	
City Charter	5.00	
Lantern rental	24.00	
A. R. Schmidt	4.70	
Cash and name books	2.50	
Excess dues — refund	7.00	
Excess bank deposit	5.00	
Letter file	.75	
One rubber stamp	.25	
Expressage	.25	
		$1 083.75
Cash on hand		792.52
		$1 876.27

(Signed) M. A. Beck, *Treasurer.*

Association of Engineering Societies.

Vol. XLIII. NOVEMBER, 1909. No. 5.

PROCEEDINGS.

Engineers' Club of St. Louis.

St. Louis, October 20, 1909. — The 674th meeting of the Engineers' Club of St. Louis was held at the Club Rooms, 3817 Olive Street, on Wednesday evening, October 20, 1909, at 8.30 o'clock, President Wall in the chair. There were present fourteen members and six visitors.

The minutes of the 673d meeting were read and approved. The minutes of the 468th meeting of the Executive Committee were read.

The following were elected: S. C. Baker (member), M. W. Cluxton (member), C. M. Daily (member), Thomas N. Jacob (member), E. H. Lawrence (member), J. D. Macpherson (member), Richard Gildehaus, Jr. (junior member).

The Secretary read an application for membership from Mr. Philip Aylett, which was referred to the Executive Committee for approval. The Secretary read a letter from the president of the Academy of Science calling attention to reports of disorderly conduct in the vicinity of the Academy building and asking the members of the Engineers' Club to report any such conduct that might come under their observation.

It was moved by Mr. Langsdorf and seconded by Mr. Bryan that the Executive Committee be authorized to make arrangements for joint meetings between the Engineers' Club of St. Louis and the St. Louis Section of the American Institute of Electrical Engineers. Motion carried.

Mr. William H. Bryan then presented a very interesting and instructive paper on "Going Value as an Element in the Appraisal of Public Utility Properties." The paper pointed out the methods used by the Wisconsin Commission in determining the magnitude of the going value as compared with the different method advocated by Mr. Alvord in a recent paper, and indicated certain simplifications that seem to be necessary in individual cases.

The lively discussion following the reading of the paper was participated in by Messrs. Bryan, Toensfeldt, Schuyler, Wall, Hendrich, Layman, Childs and Roux.

Adjourned.

A. S. Langsdorf, *Secretary.*

Technical Society of the Pacific Coast.

THE regular meeting of the Technical Society of the Pacific Coast was held on Friday, September 24, at the residence of the Secretary, 1926 Broadway.

The minutes of the last regular meeting were read and approved.

The Secretary read a paper on the subject of "The Future Water Supply for San Francisco," in which he pointed out many of the impracticable features of the project to obtain water from the Hetch-Hetchy Valley. In the course of his paper the quantities at disposal held in the reservoirs were touched upon, and great stress was laid upon the fact that under the permit obtained from the Interior Department it was necessary to bring the Lake Eleanor Reservoir to its fullest possible capacity before the Hetch-Hetchy Valley could by any possibility be considered, which makes the real problem one of a distant future. It was pointed out that the more practicable solution of the problem lay in developing the water resources in the more immediate vicinity of San Francisco, which upon proper development will yield over 100 000 000 gal. a day.

A short discussion of the paper followed.

The President appointed a committee to make arrangements to visit the present water supply of the city for the purpose of inspecting the available resources at the present time.

The committee consists of Mr. Uhlig, Mr. Homberger, Mr. A. T. Herrmann, Mr. Modina and Mr. Tower, to which were added the Secretary and the President as *cx-officio* members.

The meeting thereupon adjourned, after which the members spent a social evening as the guests of the Secretary.

OTTO VON GELDERN, *Secretary.*

SAN FRANCISCO, NOVEMBER 26, 1909. — Regular meeting of the Technical Society of the Pacific Coast held at the Hotel Argonaut, where dinner was had before the regular business of the evening was taken up.

President Dickie called the meeting to order at eight o'clock, and the Secretary read the minutes of the last regular meeting, which were approved upon motion. The following Nominating Committee was appointed to prepare a ticket of officers for the ensuing year:

Morton L. Tower, chairman; Charles E. Beugler, H. A. Brigham, Frank P. Medina and Adolf Lietz.

The President, Mr. George W. Dickie, thereupon addressed the members on the subject of "The Engineering Trades on the Pacific Coast," in which he called attention to the unsatisfactory condition in which the item of labor enters into engineering or industrial estimates at the present time, asserting emphatically that the difficulty will not be overcome until some more rational method is found which will make this factor or element a more constant one.

The remedy proposed lies in an entire change of attitude towards each other of the employer and the employed. They should become associates in the labor part of every estimate. A coöperation of these two parties, in which the representatives of labor will make their own estimate of cost, abiding by their estimate, and sharing in the ultimate profits to the extent

agreed upon between the two parties, is, in Mr. Dickie's opinion, the only rational solution of this intricate and vexed question,

The paper read by the President was discussed with great interest by Mr. Hermann Schussler, Mr. Bruce Lloyd, Mr. Harry Larkin and others.

Mr. Hermann Schussler, as guest of the Society, related some incidents of great interest to the members, after which it was arranged that this Society hold a meeting for the purpose of affording its members an opportunity to attend a lecture on the subject of the "Water Supply of San Francisco."

Mr. Schussler stated that it would give him pleasure to take eight or nine members of the Society over the works of the Spring Valley Water Company, in order to show them the actual condition and the magnitude of these works and to acquaint them with the real status of the plant which furnishes water to the city of San Francisco.

The offer to make this visit was gratefully accepted. The President instructed the Secretary to make the necessary arrangements for the lecture and the proposed trip.

The meeting thereupon adjourned.

OTTO VON GELDERN, *Secretary.*

Association of Engineering Societies.

Vol. XLIII. DECEMBER, 1909. No. 6.

PROCEEDINGS.

Boston Society of Civil Engineers.

Boston, October 20, 1909. — A regular meeting of the Boston Society of Civil Engineers was held at Chipman Hall, Tremont Temple, at 7.40 o'clock p.m., Vice-President Charles T. Main in the chair; one hundred and eighty members and visitors present, including members of the Boston Section of the American Society of Mechanical Engineers.

The record of the last meeting was read and approved.

Messrs. Theodore M. Beach, William H. Ellis, Jr., William F. Farley, Oren L. Goodridge, Edward R. Hyde, Daniel P. Kelley, John L. Mann, Stanley A. Miller, Charles W. Robinson, Conant W. Ruth, Harry F. Sawtelle and Charles E. F. Stetson were elected members of the Society.

The chair stated that he had the report of Mr. Frank S. Hart, the committee appointed to prepare a memoir of Mr. Arthur W. Hunking. As Mr. Hart was not present, on motion of Mr. Bryant it was voted that the memoir of Mr. Hunking be accepted, that its reading be dispensed with, and the Committee of Publications of the Board of Government be authorized to print same in the Journal.

The chair announced the death of William Parker, a member of the Society, which occurred on September 30, 1909. On motion of Mr. Bryant, it was voted that the president appoint a committee to prepare a memoir of our late fellow-member, William Parker, the same to be presented to the Society by title, for publication in the Journal. The president has appointed as this committee: Messrs. Walter Shepard, Herbert C. Keith and Edward A. Haskell.

In taking up the literary exercises of the evening, the chairman, Mr. Charles T. Main, said in part that it was expected that Professor Hollis, who is chairman of the Boston branch of the American Society of Mechanical Engineers, would be here to preside at the literary exercises during the latter part of the evening, when the meeting will really be in part a meeting of the Society of Mechanical Engineers.

A few months ago the Boston Society of Civil Engineers appointed a committee to consider the advisability of establishing a mechanical

section of the Boston Society. About the same time the American Society of Mechanical Engineers were discussing the advisability of starting a Boston branch of that society.

All of the members of the committee appointed by the Boston Society were members of the American Society of Mechanical Engineers, and, naturally, the question of the advisability of starting a Boston branch of the American Society of Mechanical Engineers was turned over to that committee.

But the question arose as to which would be the greater benefit to the greater number of engineers, — a mechanical section of the Boston Society, or a Boston branch of the American Society.

It appeared that the number of mechanical engineers who were members of the Boston Society of Civil Engineers was relatively small as compared with the number of mechanical engineers in the city of Boston and with the number of mechanical engineers who were members of the American Society.

In view of this, it seemed to the committee that a Boston branch of the American Society would be of greater benefit to the engineers in general than a mechanical section of the Boston Society. The committee, however, has refrained from making a final report to the Boston Society, because they do not want to have too many societies, and think it advisable that there should be a concert of methods, and that all effort should be concentrated, if possible, in one general society.

The reason for this joint meeting of the Boston Society of Civil Engineers and the American Society of Mechanical Engineers is that we might see if there be some possible way in which these two bodies can work together.

Prof. Gaetano Lanza then read the paper of the evening, which had been prepared by himself and Mr. Lawrence S. Smith, entitled, "Comparison of the Results Obtained by the Use of Three Theories of the Distribution of the Stresses in Reinforced Concrete Beams with the Experimental Results."

A general discussion followed the reading of the paper, which was participated in by Messrs. Sanford E. Thompson, Desmond FitzGerald, Robert L. Read, C. M. Spofford, H. F. Bryant, G. F. Swain and R. R. Newman, of the Boston Society, and Fred. Sumner Hinds, of the American Society of Mechanical Engineers. The Secretary also read a discussion prepared by Mr. J. R. Worcester, past President of the Boston Society of Civil Engineers.

Adjourned.

S. E. Tinkham, *Secretary.*

Boston, November 17, 1909.— A regular meeting of the Boston Society of Civil Engineers was held at Chipman Hall, Tremont Temple, at 7.45 o'clock P.M., President George B. Francis in the chair. Eighty-one members and visitors present.

The record of the last meeting was read and approved.

Messrs. Walter C. Durfee, Charles H. Dutton, Herbert T. Gerrish Philip H. Ladd, Bernard S. Rose, William T. Shaw, George R. Wadsworth and John H. Wiseman were elected members of the Society.

The Secretary presented the report of the committee appointed to prepare a memoir of our late associate, Edwin W. Ellis, and on motion it was voted to accept the report and order it to be printed in the JOURNAL.

The first paper of the evening, entitled "Waterproofing of Engineering Structures," by Joseph H. O'Brien, was read by its author, and was very fully illustrated by lantern slides. A discussion followed by the President and Messrs. Skinner, Hodgdon and Larned, of the Society, and by Mr. Edward W. DeKnight, of New York.

The second paper was by Gilbert S. Vickery, entitled "The Use of Manard Steel in Railroad Track." The paper was also illustrated by lantern slides. A general discussion followed the reading of the paper, and at its conclusion the Society adjourned.

S. E. TINKHAM, *Secretary.*

The December meeting of the Sanitary Section was held at the Boston City Club on Wednesday evening, December 1.

Mr. Ralph J. Sherriff was elected a member of the Section.

Prof. Earle B. Phelps read a paper on disinfection of sewage by means of chemicals, especially calcium hypochlorite, and Mr. George A. Johnson read a companion paper on the disinfection of water by similar means. The paper was discussed by Messrs. Kinnicutt, Winslow, Gage, Clark, Pratt and others. Sixty-nine members and guests were present.

ROBERT SPURR WESTON, *Clerk.*

Civil Engineers' Society of St. Paul.

ST. PAUL, MINN., NOVEMBER 8, 1909. — The monthly meeting of the Civil Engineers' Society of St. Paul was held in the Society's club room, in the Old State Capitol Building, on Monday evening, November 8, 1909, with President H. J. Bernier in the chair.

There were present eight members. The minutes of the previous meeting were read and approved.

The Secretary was directed to advise Mr. Martin T. Roche, president of the Northwestern Cement Products Association, that the members individually of our Society would be glad to attend the sixth annual convention of the association, which is to be held at St. Paul in March next; and that further consideration would be given his suggestion as to this Society holding any meeting during the said convention.

The Secretary was directed to advise Mr. C. A. P. Turner (member Am. Soc. C. E.) that the Society would be glad to be the recipient of a copy of one of his new books on reinforced concrete; same to be placed upon the shelves of its library.

The Secretary was authorized to arrange for the purchase of three additional units, for the elastic bookcases, also for the purchase of a copy of Vols. 29 and 30 of the Transactions of the American Society of Mechanical Engineers; and also a copy of "Principles of Reinforced Concrete Construction," by Turneaure and Maurer.

The applications of Messrs. A. J. Rasmussen for full membership, F. W. Fiske, Jr., and Jno. E. Fearing for junior membership, were

read; it was then moved, seconded and carried that the Secretary cast the ballot of the Society, electing these applicants as petitioned.

The meeting thereupon adjourned.

D. F. Jurgensen, *Secretary.*

St. Paul, Minn., December 13, 1909. — The regular monthly meeting of the Civil Engineers' Society of St. Paul was held in the Society's room in the Old State Capitol Building on Monday evening, December 13, 1909, with President H. J. Bernier in the chair. There were present eight members and one junior member.

The minutes of the previous meeting were read and approved.

It was moved, seconded and carried that the Hon. A. O. Eberhart, present governor of the state of Minnesota, be elected honorary member of the Society, the intent being that he take the place in the Society of his lamented predecessor, the Hon. John A. Johnson.

It was moved, seconded and carried that the Secretary write Mr. P. K. Pulte, requesting him to submit an amended application for full membership in the Society; it to contain his occupations up to date. This for the purpose of the further consideration of his petition for membership by the Society.

It was moved, seconded and carried that the Secretary notify all members that the question of amending Article XVII of the Constitution, to read: "The regular annual dues for resident membership shall be: for members, $5 per year; for non-resident, $2 per year; same to be effective January 1, 1910," would be taken up by the Society at its next regular meeting, which will be held on the evening of January 10, 1910, which meeting will be the regular annual meeting.

Moved, seconded and carried that the Society would hold its customary annual banquet on the evening of January 10, 1910, which is the annual meeting, same to be held in the rooms of the Commercial Club of St. Paul, and to follow the election of officers, business meeting to be called to order at 6.30 P.M. in the secretary's room of the said Commercial Club. Banquet to follow at 7.30 P.M. Messrs. Wolff and Armstrong were appointed a committee to arrange for the banquet and use of the secretary's room for the business meeting; Messrs. Palmer and Mitchell were appointed a committee to arrange for music.

The Secretary was directed to advise certain delinquent members of the amounts they were indebted to the Society and to urge immediate payment of such accounts.

The Secretary was directed to invite the president and secretary of the Minneapolis Engineers' Club, Mr. Andrew Rinker, city engineer of Minneapolis, Mr. George W. Cooley, secretary and engineer for the Minnesota State Highway Commission, and Mr. L. W. Rundlett, Commissioner of Public Works, St. Paul, to attend our banquet.

The Secretary was directed to acknowledge receipt of copy of "Concrete Steel Construction by Turner," and to express to Mr. C. A. P. Turner the thanks of the Society for his generous donation.

The meeting thereupon adjourned.

D. F. Jurgensen, *Secretary.*

Montana Society of Engineers.

Butte, Mont., November 13, 1909. — The monthly meeting of the society for November was called to order at the appointed hour, Mr. J. H. Harper presiding. Minutes of prior meeting approved.

The Committee on Nomination of Officers for the ensuing year recommended the following list:

President — Frank M. Smith.

First Vice-President — F. W. C. Whyte.

Second Vice-President — Robert A. McArthur.

Secretary and Librarian — Clinton H. Moore.

Treasurer and Member of the Board of Managers of the Association of Engineering Societies — Samuel Barker, Jr.

Trustee for Three Years — John D. Pope.

The report was adopted and the Secretary instructed to send out ballots.

The resignation of Harry C. Wilmot was presented and accepted.

The Secretary reported the transfer of the following members to the Corresponding Member Class: Messrs. Wynne, Wright, Tannatt and C. H. Repath to membership in the Utah Society of Engineers.

On motion, Butte was selected as the place for holding the next annual meeting, January 6, 7, 8, 1910, and the chair named the following Committee of Arrangements: John C. Adams, Robert A. McArthur, John D. Pope.

Mr. J. H. Ellison, one of the charter members of the society, gave a very interesting account of the building of the St. Paul Pass Tunnel, in western Montana, on the line of the Milwaukee, St. Paul & Puget Sound Railway, and the members showed their appreciation of the information given by a unanimous vote of thanks.

Adjourned.

Clinton H. Moore, *Secretary.*

Butte, Mont., December 11, 1909. — The December meeting of the Society was called to order by President C. H. Bowman, with a quorum present. The minutes of the last meeting were read and approved. The Secretary presented the application of Mr. Charles H. Hills for membership in the Society, and the same being approved, the usual ballot was ordered. The Committee of Arrangements for the annual meeting gave a verbal report and was given further time to complete their labors.

Adjournment.

Clinton H. Moore, *Secretary.*